FEB 5 1925

Engineering Library


# ENGINEERING:

## An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIX.—No. 3082. [Registered at the General Post Office as a Newspaper.] LONDON: FRIDAY, JANUARY 23, 1925. [DOUBLE NUMBER WITH INDEX. PRICE ... 2s. BY INLAND POST ... 2s. 3d.



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Steam & Crude Oil Road Rollers, &c.
2581

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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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*See half-page Advert. last week and next week.* 2087

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See Advertisement last week, page 13.

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PATENT BOILERS *See Page 53, Jan. 16.* 1994
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Specification and Workmanship equal to Main Line Locomotives.
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SPECIALISTS
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PLANT AND MACHINERY
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ENGINEERING WORKS,
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See Advertisement, page 33.

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Worm Wheels cut up to 13 ft. diam.
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*Systems*
PRESSURE AIR, STEAM
*For Boilers of all types.*
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*Naval Outfits a Speciality,*
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C.4. 2537

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GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
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ENGINES:—"Uniflow," "Corliss," or Drop Valve.
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GENERATING SETS, Totally Enclosed, Three Crank Self-Lubricating Engine, with Complete Condensing Plant, by Allens, Pipes, Valves, Oil Separator, Etc., complete.
Admirably suited for Mining or other power transmission work.
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See Advertisement, page 58. 2584

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REFRIGERATING PLANT. 1475
See Advertisement, page 49, Jan. 16.

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GROUND extending to 42,672 square yards, and BUILDINGS thereon of Engine and Boiler Shops (lately belonging to Messrs. DUNSMUIR & JACKSON, Ltd.), equipped with Overhead Travelling Cranes up to 60 tons.
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**Matthew Paul & Co., Ltd.,**
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See Full Page Advt., page 53, Jan. 2.

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**Walter Somers, Limited,**
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 57, Jan. 2. 8195

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LIMITED.
See Advertisement page 56. 2402

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T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E.15. 1794

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Belt Flywheels, 16ft. diam. by 26in. wide. Corliss Valves to inlet and exhaust of both cylinders. Vertical Air Pump and Condenser below floor level, worked by L crank from L.P. Crosshead.
A LARGE SELECTION OF SINGLE CYLINDER HORIZONTAL ENGINES by Tangyes, Marshall, Robeys, etc.
THOMAS MITCHELL & SONS, LTD., EDGAR STREET, BOLTON.
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**Electric Cranes.**
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## The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005


PATENTS AND DESIGNS ACTS, 1907 & 1919.

## Notice is Hereby Given that

The Firm Stachelband, G.m.b.H., of Unten den Linden 56, Berlin, Germany, seek leave to amend the Specification of Letters Patent No. 223493, granted to them for "Improvements in the method of, and apparatus for, punching strip iron."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 14th January, 1925.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2. within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General.

HERBERT HADDAN & CO., Chartered Patent Agents, 31 & 32, Bedford Street, Strand, W.C.2. G 985


## Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

## Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 768


## TENDERS.

HIS EXALTED HIGHNESS THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Board of Directors of His Exalted Highness The Nizam's Guaranteed State Railways Company, Limited, are prepared to receive

## Tenders for the Supply of :—

13,097 TRANSVERSE STEEL SLEEPERS, weighing 153 lbs. each.

For each copy of the Specification a fee of Ten Shillings will be charged, which is not returnable. Tenders enclosed in sealed envelopes, addressed to the Chairman and Directors, and endorsed, "Tender for Steel Sleepers," must be delivered at the Company's Offices not later than Twelve Noon, on Wednesday, 4th February, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
F. ADAMS, Secretary.

271, Winchester House,
100, Old Broad Street,
London, E.C. 2.
20th January, 1925. G 992

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

## Tenders for Providing and

LAYING a 6-in. CAST-IRON WATER SUPPLY PIPE, from an existing main to the men's bathing lake at Victoria Park, London, E.

Forms of Tender and Conditions of Contract, together with Plans and Specifications, may be obtained from the Chief Officer, Parks Department, The County Hall (Room 393e), Westminster Bridge, S.E.1.

Tenders must be delivered to the Clerk of the Council at the County Hall, not later than Four p.m. on 10th February, 1925. No Tender received after this time will be considered.

The Council does not bind itself to accept the lowest or any Tender,

JAMES BIRD,
Clerk of the London County Council. G 983

MERTHYR TYDFIL UNION.

HEATING, DOMESTIC HOT WATER AND LAUNDRY INSTALLATION.

## Tenders are Invited by The

Guardians of the Merthyr Tydfil Union for NEW HEATING and DOMESTIC HOT WATER SUPPLY INSTALLATION, together with additions and alterations to Laundry Plant, NEW STEAM MAINS, etc., for the Workhouse, Merthyr Tydfil.

The Contractors will be required to pay their workmen not less than the standard rate of wages, and comform to the recognised rules and regulations in the district.

Specification, Conditions of Contract and Drawings may be inspected at the Union Offices of the above Guardians, 44, Thomas Street, Merthyr Tydfil, and copies of same, with Form of Tender, will be forwarded on application, accompanied by a deposit of £4 4s. (Four Guineas), which will be refunded on receipt of a *bona fide* Tender.

The site can be inspected by Contractors by appointment with the Master any weekday during normal working hours, on production of Copy of Specification at the Workhouse Lodge. Any further particulars can be obtained from the Consulting Engineer, Mr. HERBERT BROWN, 2, Park Grove, Cardiff by appointment.

Sealed Tenders, endorsed, "Heating and Laundry Installation," and addressed to the undersigned, to be delivered not later than Noon, of Feb. 21st, 1925.

FRANK T. JAMES,
Clerk to the Guardians.

Union Offices,
44, Thomas Street,
Merthyr Tydfil, Glam.
17th January, 1925. G 988

COUNTY BOROUGH OF BELFAST.

TO ENGINEERS.

The EDUCATION COMMITTEE invite

## Tenders for the Supply and

DELIVERY of COOKING EQUIPMENT and APPARATUS.

Specification and Form of Tender may be obtained at the Office of the Education Architect, College Square, Belfast.

Parties tendering must comply with the Council's Standing Orders relating to Wages, Hours of Labour, etc.

Sealed Tenders on Forms provided, endorsed "Tender for Cooking Equipment," to be lodged in my office not later than Ten a.m., on Thursday, 29th January, 1925.

An Official Receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

The lowest or any Tender will not necessarily be accepted. G 991

R. MEYER, Town Clerk.

FIRE SERVICE.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, Etc., are prepared to receive

## Tenders, before Eleven

a.m., on Tuesday, 10th February, 1925, for the INSTALLATION of Additional FIRE SERVICE, at the Post Office Stores Factory, Birmingham.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities and Forms for Tender, &c., may be obtained from the Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W. 1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, &c.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. G 994

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY CO.

ELECTRIFICATION OF BOMBAY SUBURBAN LINES.

The Directors are prepared to receive

## Tenders for the Supply and

Erection, in India, of the following PLANT:—(1) OVERHEAD EQUIPMENT OF PERMANENT WAY and OVERHEAD TRANSMISSION AND DISTRIBUTION LINES.

Fee for Specification, £2 per copy.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

Tenders must be submitted in duplicate, and must be sealed and addressed to the undersigned, marked, "Tender for Overhead Equipment, etc.," and delivered not later than Noon, on Monday, 9th March, 1925.

The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Bombay, Baroda and Central India Railway Company.

The Directors do not bind themselves to accept the lowest or any Tender.

The Consulting Engineers, to whom application for any further technical information may be made, are Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, S.W.1.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
19th January, 1925. G 993

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF STORES, ETC.

The Metropolitan Water Board invite

## Tenders for the Supply of the

undermentioned STORES, etc., for the periods of six or twelve months, commencing 1st April, 1925, as the Board may decide:

Tender No.

1. Bricks, Firebricks, Cement, etc.
2. Brushes, Brooms and Handles.
3. Cast Iron Pipes and Irregular Castings.
5. Cotton Waste, Engine Wipers and Mutton Cloths.
6. Hemp, Yarn, Rope, House-Flannel, Mats, etc.
7. Hire of Horses, Carts and Petrol Lorries, and supply of Sand and Ballast.
8. Iron and Steel.
9. Bolts and Nuts, Screws, Files, Taps, Shovels and Picks.
10. Lead, Brass, Copper, Zinc and Glass.
11. Repair of Meters (Siemens).
12. Fuel Oil, Oils (Lubricating), Kerosene, Motor Spirit, Greases, Tallow, etc.
13. Oilman's Sundries, Soap, Tar, Gas Mantles, Metal Polish.
14. Packings, Rubber Goods, etc.
15. Paints, Varnishes, Linseed Oil, Turpentine, etc.
17. Pipelaying Repairs, Alterations, etc.
18. Scrap Iron, Purchase and Removal of.
19. Small Iron, Brass, Gunmetal and other Castings.
20. G.M. Stopcocks and Ferrules.
21. Sluice Valves and Spindles, Hydrants, G.M. Outlets and Caps.
22. Timber, Hard and Soft Woods.
23. Maintenance of Weighing Machines.
24. Electric Lamps.
26. Furnace Refuse, Disposal of.

Tenders must be made on the official forms, which may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, on and after Thursday, 22nd January, 1925, by personal application (Room 156), or upon forwarding a stamped, addressed brief envelope.

Applicants should refer to the number of the Tenders for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, Clerkenwell, E.C.1," and endorsed "Tender for....," must be delivered at the Offices of the Board (Room 122) not later than Eleven a.m. on Wednesday, 11th February, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, Clerkenwell, E.C.1.
15th January, 1925. G 989

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

## Tenders for :—

1. DOG SPIKES.
2. STEEL FISHBOLTS and NUTS.
3. VACUUM BRAKE HOSE PIPES.
4. GLASS SHEET and PLATE, BULL'S EYE LENSES and COTTON LAMP TAPE.
5. MISCELLANEOUS RAILWAY STORES, including hinges, measuring tapes, whiting, borax, prussiate of potash, Bath bricks, Lieuvain's lubricators, needles, sieves, soap, linen thread, etc.

Tenders due on the 30th January, 1925, for Nos. 1 and 2, on the 3rd February, 1925, for No. 3, and on the 6th February, 1925, for Nos. 4 and 5.

Tender forms obtainable from above. H 8

## APPOINTMENTS OPEN.

LOUGHBOROUGH COLLEGE.
Loughborough,
Leicestershire.

Dr. H. SCHOFIELD, M.B.E., PRINCIPAL.

DEPARTMENT OF AUTOMOBILE ENGINEERING.

## Applications are Invited for

the POSITION of HEAD OF the AUTOMOBILE ENGINEERING DEPARTMENT. Candidates should be graduates of a British University, and have had practical experience in the design and manufacture of Automobiles. The scale of salary ranges from £450 to £650 by annual increments of £25, and the commencing salary will depend upon the qualifications and experience of the applicant.

All applications, with copies of not more than three recent testimonials, should be forwarded before January 28th to the REGISTRAR, from whom any further particulars may be obtained. G 926

ROYAL SCOTTISH MUSEUM, EDINBURGH.

TECHNOLOGICAL DEPARTMENT.

THE SCOTTISH EDUCATION DEPARTMENT are prepared to

## Nominate Candidates for the

POST of ASSISTANT in the TECHNOLOGICAL DEPARTMENT of the Royal Scottish Museum. The normal salary on commencement is £250, rising, if service is approved, by annual increments of £20 to £450, and thence under certain conditions by annual increments of £25 to £700. A cost of living bonus on the scale applicable to the Civil Service is also payable at present. The post is a Civil Service one and is pensionable.

Candidates should be graduates in Engineering or hold similar educational qualifications, and must be able to satisfy the Civil Service Commissioners that they have received such systematic education, general and technical, as in the Commissioners' opinion fits them for the post. Workshop experience is essential. The normal age limits are 26 to 30, but in special circumstances, candidates under 26 or over 30 may be accepted. Further information regarding the method and conditions of appointment may be obtained from the Director of the Museum.

Applications for nomination, stating age and qualifications and accompanied by three recent testimonials, should be made in writing to the DIRECTOR, before 14th February, 1925. Nominated candidates, after passing a written examination, if necessary, will be interviewed by a Selection Board. G 959

KENT EDUCATION COMMITTEE.

ERITH TECHNICAL INSTITUTE.

## Required, Immediately, a

TEACHER of GAS SUPPLY, for Three Evenings per week. The classes are attended by local apprentices. Salary in accordance with the scale of the Kent Education Committee.

Send particulars of qualifications and experience to the PRINCIPAL, Technical Institute, Erith Road, Belvedere, Kent.

E. SALTER DAVIES,
Director of Education.
19th January, 1925. H 2

## Wanted, for Permanent Staff,

Station Construction Dept., COMPETENT ENGINEER with experience of construction work and good technical training. State age. Salary according to qualification.—Address, THE YORKSHIRE ELECTRIC POWER CO., 36, Park Place, Leeds. H 3

COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

ELECTRICAL TESTING ENGINEER—BARKING POWER STATION.

## Applications are Invited for

above POSITION. Applicants must have previous experience in the manufacture and operation of instruments and accessories in connection with standard types of protective gear, and preference will be given to one having held a similar position with a supply undertaking. The Engineer appointed will be responsible for the supervision and maintenance of the protective gear on a large system, and generally to take charge of the department. Salary required, which will depend on experience, to be stated, together with particulars of age, experience and copies of testimonials and when at liberty, to be posted to the MANAGER & SECRETARY, County of London Electric Supply Co., Ltd., Moorgate Court, Moorgate, London, E.C 2. H 5

## Engineering Journalist Re-

QUIRED for Publicity Staff of large engineering firm. Experienced in preparation of Press Articles, preparation of catalogues and sales leaflets. State age, salary required, etc.—Address, G 972, Offices of ENGINEERING.

## Foundry Manager Wanted,

by large Engineering Firm in the East Midlands. Must be first-class man experienced in repetition production of soft iron castings, malleable castings, brass, and small quantity of steel castings. Must be energetic, good organiser, capable of controlling men and methods for good quality production.—Address, stating age, experience and salary required, G 977, Offices of ENGINEERING.

## Foundry Manager Required

for Iron and Steel Foundry, must have had a thorough practical training and be a good disciplinarian, up-to-date knowledge of Moulding Machines and expert experience on Cupola Practice and mixing by Analysis. A knowledge of Semi-steel, also Electric Steel Furnaces desirable.—Address, in confidence, stating experience, references and wages required, G 927, Offices of ENGINEERING.

## Required for Important

Argentine Railway, TWO ENGINEER DRAUGHTSMEN, with knowledge of the design of Bridge abutments, retaining walls, arches, foundations and drainage. Railway experience desirable. Age 24 to 32, single. 3 years' contract at £400, £450 and £500 p.a. for 1st, 2nd and 3rd years respectively, free passage out and home.—Write, giving full particulars of education, training and experience, age, with copies (only) of testimonials, BOX C.L.D., c/o DAVIES & CO., 95, Bishopsgate, E.C.2. H 11

## Oil Engine Designer Wanted

by prominent oil engine manufacturer in the United States. Must be qualified to design both horizontal and vertical two-stroke cycle engines of the airless injection cold-starting type, in sizes of 50 to 500 HP.—Address, giving full particulars of experience, education, age and salary, BOX 268, MCGRAW-HILL PUBLISHING CO., LTD., 6/8, Bouverie Street, London. G 943

## Required, Immediately, In-

SPECTING ENGINEER for Northern France; also one for Germany (Ruhr), with experience of inspection, testing all classes Railway Materials and Steel for Structural work; good knowledge of language and highest credentials essential; state salary required and previous experience.—Address, G 990, Offices of ENGINEERING.

## Engineer, accustomed to

preparing Tenders for Turbine Plant and Power Station Equipment. Application, stating age, training, experience and salary required. —Address, G 976, Offices of ENGINEERING.

## Wanted, Mechanical and

ELECTRICAL ENGINEER for Steelworks; must be thoroughly conversant with tyre mills, steam hammers, hydraulic presses, furnaces, and general steelworks plant. Also electrical equipment.

Applicants should state age, salary required, full details of experience, etc.—Address, G 962, Offices of ENGINEERING.

## Wanted, Draughtsman, ex-

perienced in Gas and Chemical Plant; must be familiar with gas purification and by-product installations.—Address, giving full detail particulars and salary required, G 970, Offices of ENGINEERING.

## Draughtsman Required, with

good experience of design of Semi-Diesel and Cold Starting Oil Engines.—Address, stating age, salary and full particulars, G 965, Offices of ENGINEERING.

## Required, by large Engineer-

ing Firm in Midlands, a LEADING ENGINEER-DRAUGHTSMAN for internal-combustion engines for industrial and marine purposes. Good scope for suitable man who must also have some knowledge of steam engines.—Address, giving age, qualifications and references, state when at liberty, and what salary expected, G 978, Offices of ENGINEERING.

## Required, by London Firm,

DRAUGHTSMAN experienced in design of all kinds of Steel Works Furnaces and Gas Producers. —Address, stating age, experience and salary required, G 979, Offices of ENGINEERING.

## Draughtsmen and Assistant

ENGINEERS REQUIRED in London for structural steel and reinforced concrete. State age, technical education, experience, salary required.—Address, G 974, Offices of ENGINEERING.

## Wanted, Mechanical

Draughtsman with general works experience and knowledge of lay-out of steam plant and ventilating and cooking installations.

Applicants should state salary required and give particulars of their age and military service, and forward testimonials and other records of their past experience in the class of work required.—Write, B.D. c/o CHARLES BARKER & SONS LTD., 31, Budge Row, E.C.4. G 981

## Wanted, for Large Chemical

Works in the Midlands, ASSISTANT POWER ENGINEER with technical knowledge and practical experience of R.H.T. and L.T. power supply, economical steam production, hydraulics, refrigeration, etc. Full particulars of experience, age and salary required.—Address, G 997, Offices of ENGINEERING.

## The South Metropolitan

GAS COMPANY HAS a VACANCY for an ENGINEER with wide experience in the design, construction, erection and repair of Gasholders, Retort and other manufacturing plant and structures of the kind used in Gas Works and Coke Oven Recovery.

Applications, giving age, full particulars of qualifications, experience, military service and salary required, should be made in writing to the undersigned before 7th February, 1925.

By Order,
FRANK DAY,
Secretary.

709, Old Kent Road,
London, S.E. 15.
22nd January, 1925. H 9

THE COUNTY OF LONDON ELECTRIC SUPPLY COMPANY, LIMITED.

TURBINE ENGINE DRIVERS.

## Applications are Invited for

above, experience in handling large high speed turbo generator units, preferably of the Parsons type, essential. Eight hour shifts.—Applications to the RESIDENT ENGINEER, Barking Power Station, Creekmouth, Barking. H 10

## THE THERMAL EFFICIENCY OF POWER STATIONS.

By R. H. PARSONS, M.I.Mech.E., M.E.I.C.

IT is the general practice to compare the operating results of power stations on the basis of thermal efficiency, and there is a keen competition between the various plants to secure the most creditable figures. The fact that the cheapest production of power is not always associated with the highest thermal efficiency may be freely admitted. It may not pay to incur the heavy capital expenditure necessary to secure the lowest fuel consumption in localities where fuel is cheap, but it is nevertheless true that it is the bounden duty of every engineer to turn the greatest possible percentage of the heat in the fuel he uses into useful work. The thermal efficiency of his station is the measure of his success in doing this, so that it is of the highest importance that there shall be agreement as to the method of computing this efficiency and an understanding as to the degree of precision with which the result can be arrived at. All physical measurements are uncertain beyond a given point. A ton of coal is a perfectly definite quantity, but even in a laboratory it would be impossible to say that a given consignment weighed neither more nor less than 2,240 lb. Under commercial conditions a margin of a good many pounds has to be allowed for inaccuracies of weighing machines and inexactness on the part of the operators. Similarly in the measurements of water, steam, electricity, $CO_2$, temperature and all the other quantities which concern the efficiency of power stations, there are of necessity, limits of accuracy which it is impossible to exceed.

All errors in measurement, of course, affect the final determination of thermal efficiency; hence it is worth while examining the degree of accuracy with which the essential factors of the calculation can themselves be determined. Before doing this, however, the basis upon which thermal efficiency should be computed, will be discussed in order, if possible, to ensure that the fairest possible comparisons may be made between different plants. Defining thermal efficiency as the proportion of the heat in the fuel which is turned into electrical energy, it is evident that there are only three quantities which enter into the calculation, namely, the calorific value of the coal, the weight of coal used and the amount of electricity produced in the period over which the thermal efficiency is to be computed. These we will consider in the order stated.

The calorific value of coal is unfortunately expressed in several different ways, but the basic figure upon which the various values are founded is that which is determined experimentally by the calorimeter. This figure, which we shall call the calorimeter figure, is the heat given up by the burning of a pound of dry coal, when the products of combustion have been reduced to practically the original temperature. The calorimeter figure, then, is our starting point, although it is subject to its own errors which will be discussed later. The first objection to the use of the calorimeter figure for determining the thermal efficiency is that this figure does not represent the value of the coal as fired, because part of the weight of the latter is made up of moisture which was driven off before the calorific test was taken.

By modifying our calorimeter figure in the proportion which the dry coal bears to the damp coal we get a second calorific value, which is often called the "as fired" value. The moisture in the coal is not a mere adulterant, however. It passes off in the form of vapour when coal is burnt in a furnace, and carries away not only its latent heat but its sensible heat at the temperature of the flue gases. If we make allowance for the heat so carried away we get a third calorific value for the fuel. Coal, furthermore, generally contains a considerable percentage of hydrogen, and this forms water by combustion. The heat due to the combustion of this hydrogen is, of course, recorded by the calorimeter, but the water formed passes away as vapour, when the coal is used in a furnace, and the loss of its latent and sensible heat is quite material. If these are allowed for we get a fourth calorific value for the fuel. Each of the last two calorific values is often referred to as the "lower calorific value," a practice which leads to much confusion, which is intensified by the fact that some engineers think that the vapour temperature should always be assumed as 212 deg. F., while others take some value nearer the actual temperature of the flue gases.

To give an idea of the variations of calorific value which would be recorded for the same sample of coal according to which of the above methods is employed, we will consider a coal having the proximate analysis tabulated in the usual form below.

| | Per cent. |
|---|---|
| Moisture ... ... ... ... | 8·56 |
| Volatiles ... ... ... ... | 31·28 |
| Fixed carbon ... ... ... ... | 59·10 |
| Ash ... ... ... ... ... | 9·62 |

Calorimeter value, 13,280 B.Th.U. per lb.

We will also assume that an ultimate chemical analysis has shown 4·5 per cent. of the dry coal to consist of hydrogen.

The four calorific values to which we have referred above will work out as follows for the sample of fuel under consideration.

| | B.Th.U. |
|---|---|
| (*a*) Calorimeter value ... ... | 13,280 |
| (*b*) Calorific value (as fired) ... ... | 12,143 |
| (*c*) Lower calorific value (moisture only) ... ... ... ... | 12,047 |
| (*d*) Lower calorific value (including hydrogen) ... ... ... | 11,635 |

The two values (*c*) and (*d*) have been computed on the assumption that the water vapour in each case passes away at a temperature of 212 deg. F. If a higher temperature more nearly representing the usual flue temperature was assumed, the values would of course be less than stated, and there is a temptation for engineers to calculate on the basis of flue temperature, because the lower the figure taken for the calorific value, the higher is the resulting figure of thermal efficiency.

In choosing a method of computing the calorific value of coal, we have two decisions to make. The first question is whether the calorific value should be the figure obtained for dried coal in the calorimeter test, or whether it should refer to the coal "as fired." So far as the practical man is concerned there can only be one answer. The owner of a plant does not buy dried coal, but coal containing always more or less moisture. He pays for this moisture as part of the coal just as he pays for ash in the coal. His only reason for concerning himself with calorific values at all is to know how much heat per pound it is theoretically possible to obtain from various samples of the stuff he buys. Two different samples of coal, one containing, say, 5 per cent. of moisture and the other containing 10 per cent., might show identical calorific values after drying, though obviously their commercial values in the damp state would not be identical. To treat two such coals as equivalent one to the other, as they would appear to be unless the calorimeter figures were corrected to allow for the different moisture contents, would be absurd. Hence it appears indisputable that the calorimeter figure for dried coal should always be modified by a simple calculation so as to give a calorific value representative of the fuel "as fired."

The second question which arises is whether the "higher" or "lower" calorific value should be taken. The lower value is that which is obtained by deducting the heat carried away by water vapour mixed with the other products of combustion. The water vapour is derived from two sources, firstly, the moisture present in the fuel, and secondly, and much more important, the water formed by the combustion of the hydrogen in the fuel. The vapour formed in the calorimeter is condensed, its latent heat being therefore included in the calorimeter figure. In actual boiler practice the products of combustion escape at a high temperature, so that all the latent heat in the water vapour is lost. In the case of the typical coal we have considered above, 96 B.Th.U. per lb. of fuel "as fired" are carried away by the evaporation of the original moisture, while a further 412 B.Th.U. are lost by the vapour formed by the hydrogen. These together amount to 508 B.Th.U. or over 4 per cent. of the heat in the coal "as fired."

It is sometimes argued that to deduct this amount of heat from the calorific value of the fuel "as fired" is a perfectly legitimate procedure on the grounds that it is not possible to reduce flue temperatures below 212 deg. F. in practice, as the water vapour would be condensed and make operation impossible. Combustion of a ton of the coal we have been considering would thus result in the presence of more than 1,000 lb. weight of water, and were the condensation of water to take place at this rate in the flues it would result in conditions quite impossible to deal with in present-day plants.

This point of view, which has been seriously put forward in a recent book on boiler testing, is not only theoretically absurd, but is convincingly disproved by the fact that large boiler-plants are being operated with flue temperatures well below 212 deg. Water vapour will not be condensed until the dew-point is reached, and the fact that a flame of hydrogen, the product of combustion of which is pure water, will burn in an ordinary room without causing any visible wetness, shows that water vapour will exist as a gas at temperatures lower than found in any flue, provided that its "partial pressure" is low. No visible water is deposited in the chimney of a domestic fire grate, where the temperatures are below 212 deg., and similar conditions obtain in a boiler flue. Hence there are no rational grounds for taking 212 deg. F. as a final temperature, and it is even more arbitrary to assume any higher figure. The only scientific way is to credit the coal with the whole of the heat it can produce, the products of combustion being reduced to the original temperature of the air passing to the fire. In other words, the "higher calorific value of the coal as fired" is the only true measure of the heating value of the fuel.

The use of the lower calorific value cannot be justified on any real grounds. The assumed temperature of 212 deg. for the flue gases does not correspond to actuality, any more than does the assumption of atmospheric temperature. Moreover the correction for hydrogen which the use of the lower calorific value involves, requires an ultimate analysis of the coal, a proceeding which no ordinary engineer has the apparatus or the knowledge to carry out. By taking the "higher value," we have a figure which is merely the calorimeter figure corrected simply for the percentage of moisture in the raw coal. It is indeed the simplest value that can be taken, short of using the calorimeter figure itself, which we have shown to be unjustified. The use of the "lower calorific value" might involve us in the absurdities of efficiencies of more than 100 per cent., should engineering advancement ever bring about the recovery of the latent heat of the flue-gases.

Since the above was written it has been announced that the Committee engaged upon the standardisation of boiler tests, have decided to recommend the use of the higher calorific value of the fuel in place of the lower calorific value which was advised by the earlier Committee in 1913, and it is to be hoped that the ideal final temperature of the flue gases will be taken as that of the incoming air.

Taking it, then, as demonstrated that the "higher calorific value of the coal as fired" is the value upon which thermal efficiencies ought always to be computed, we have next to consider with what degree of accuracy this figure can be obtained. In this connection there are again two questions to consider, firstly, with what accuracy can the calorific value of a single sample be determined, and secondly, within what limits can any sample be regarded as representative of the bulk. The destruction of the portion of the sample actually tested, prevents, of course, any subsequent test of the identical portion for checking purposes, so that we are compelled to assume that all portions of the same sample should give the same results, and that any discrepancy between tests of the same sample must be due to unavoidable errors of the operator or the instrument. With regard to this point we may quote the paragraph entitled "Accuracy of Results" from the Interim Report on Methods of Analysis of Coal," published by the Fuel Research Board of the Department of Scientific and Industrial Research. This paragraph is as follows: "Assuming that a thermometer is used which has been calibrated by

systematic observations of separated thread-lengths, a closer agreement than 30 B.Th.U. must, generally speaking, be regarded as accidental; if the reading error is 0·001 deg. C., the possible error resulting from this alone is 18 B.Th.U. Since the calorific value of a coal expressed in British thermal units is usually between 10,000 and 15,000, the fifth figure has no meaning, and should be rounded off to "0"; the fourth significant figure is uncertain to two or three units."

Taken literally, this appears to mean that if a calorimeter test gave a value, for instance, of anything from 12,181 to 12,189 inclusive that the result should be stated as 12,180 B.Th.U. with a "probable error" of 25 B.Th.U. On inquiry of the Fuel Research Board, as to what exact meaning was to be attached to the words quoted, we were informed that the statement "merely conveys the information that the operator may expect the results to differ by as much as 0·3 per cent., using the same thermometer and apparatus. This represents the maximum error which a competent observer would tolerate. The statement that "the fifth figure has no meaning and should be rounded off to 0," denotes that if the calorific value were found to be between 12,181 and 12,189, it should be rounded off to 12,180 or 12,190, whichever is the nearest figure found." In view of the statement in the report that "a closer agreement than 30 B.Th.U. must generally speaking be regarded as accidental" it is interesting to note that 0·3 per cent. (or 30 B.Th.U. in a 10,000 B.Th.U. sample) is the "maximum error which a competent observer would tolerate." He must apparently reject all tests which differ by more than 0·3 per cent., from some figure which he imagines to be correct and rely on those the results of which "must, generally speaking, be regarded as accidental." The state of mind of the Fuel Research Board with regard to this very important question must be judged in the light of these remarks. With ordinary calorimetry carried out under commercial conditions as in the test room of a power house, the errors are clearly liable to exceed those of a physical laboratory. As the accuracy of the calculation of the thermal efficiency of a boiler plant, or of a complete power plant is dependent upon the accuracy with which the calorific value of coal can be determined, it is of the greatest importance that the degree of attainable accuracy shall be understood, so that undue reliance shall not be placed upon doubtful figures. To show the sort of results which are obtained in practice we give in tabulated form comparative tests made by different observers upon the same samples of coal.

The columns marked "A," "B" and "C" in Table I gives the results obtained from tests made

TABLE I.—*Scotch Washed Peas.*

| | A | B | C | Mean value. |
|---|---|---|---|---|
| Total moisture, per cent. | 11·22 | 10·79 | 10·2 | 10·74 |
| Volatiles, per cent. .. | 35·12 | 35·05 | 35·0 | 35·06 |
| Fixed carbon, per cent. .. | 51·27 | 52·36 | 54·0 | 52·54 |
| Ash per cent. .. .. | 13·61 | 12·61 | 11·0 | 12·41 |
| Calorimeter value, B.Th.U. .. .. | 12,255 | 12,490 | 12,350 | 12,365 |
| "As fired" value, B.Th.U. | 10,880 | 11,140 | 11,090 | 11,037 |

upon a sample of coal by two independent laboratories and by a power station using the fuel. The greatest variation is to be found in the figures for moisture and ash. The disagreement as to the moisture contents is largely responsible for the variation in the figures for the "as fired" calorimetric value of the fuel, for there is a very fair concordance between the calorimeter values obtained on the dried fuel. It is somewhat disconcerting to note the variation in ash percentage noted by the different observers. Ash is the one thing about which it might be expected that different observers would agree. The estimation of moisture, volatile matter and fixed carbon all depend to a certain extent on the trained judgment of the observer, but ash, defined as the incombustible portion of the coal, is a perfectly definite quantity which should be determinable with as much precision as the chemical balance is capable of. If it is possible for competent observers to get results varying from 11·0 to 13·61 per cent. on a single sample, we are practically driven to the conclusion that the distribution of ash through coal is so erratic that the proportion even in two portions of a crushed and carefully mixed sample may vary widely.

For comparison with the above results, we give in Table II a similar series of three tests made on

TABLE II.

| | D | E | F | Mean value. |
|---|---|---|---|---|
| Total moisture, per cent. | 12·20 | 14·45 | 9·01 | 11·89 |
| Ash, per cent. .. .. | 20·50 | 20·40 | 18·56 | 19·82 |
| Calorimeter value, B.Th.U. .. .. | 11,110 | 11,180 | 11,420 | 11,237 |
| "As fired" value, B.Th.U. .. .. | 9,755 | 9,565 | 10,391 | 9,904 |

one sample, by different observers. As before, one test was made in a power station test room and the others in independent laboratories.

This table shows a considerably greater variation from the mean, and a discrepancy between individual tests which is sufficient to show how unsatisfactory it would be to accept or condemn a fuel on a single sample. As yet another example of the point we wish to make, we give in Table III tests made at

TABLE III.

| | Sample of Coal No. 1. | | Sample of Coal No. 2. | |
|---|---|---|---|---|
| | G | H | K | L |
| Moisture .. .. .. | 10·29 | 9·77 | 8·09 | 7·15 |
| Volatiles .. .. .. | 30·50 | 32·53 | 32·25 | 34·11 |
| Fixed carbon .. .. | 61·31 | 59·15 | 55·38 | 53·53 |
| Ash .. .. .. | 8·19 | 8·32 | 12·37 | 12·36 |
| Calorimeter value, B.Th.U. .. .. | 13,704 | 13,425 | 12,274 | 12,614 |
| "As fired" value, B.Th.U. .. .. | 12,294 | 12,114 | 11,713 | 11,281 |

two different power stations who exchanged samples of coal for the purpose. The experience and skill of the observers, and their anxiety to procure the most exact results possible render the tests of special value for comparative purposes. The first two columns "G" and "H" refer to a sample of one kind of coal as tested by the two stations, while columns "K" and "L" refer to tests by the same observers upon a single sample of another class of coal. It will be noted from Table I that three observers can differ as much as 235 B.Th.U. in their tests on a single sample of dried coal. Table II shows a discrepancy of 310 B.Th.U. between three other observers, while Table III shows a pair of observers to differ by 279 B.Th.U. in one case and by as much as 340 B.Th.U. in another case.

If we consider the calorific value of the coal "as fired" we find discrepancies of 260, 826, 180 and 432 B.Th.U. respectively in the four sets of tests. The calorific value "as fired" is, as we have shown, the figure upon which the calculation of thermal efficiency of boilers or power plants should be based, and it is disconcerting to see how greatly competent observers can differ in their estimate of this value. The divergence between their figures is wider than in the case of the "dried coal" tests because the "as fired" results are of course affected by the additional error due to the estimation of the moisture content. Taking the average value of the tests in each case to be the correct figure for the calorific value "as fired" we find errors of individual tests to vary between + 487 B.Th.U. or 4·92 per cent. of the mean to — 216 B.Th.U. or 1·9 per cent. of the mean of the respective samples.

That divergencies such as we have indicated can occur in the estimation of calorific values, when the tests which are compared have been carried out on different portions of the same sample by men with no object at all except to get at the truth, is quite sufficient to show how unsafe it is to place too much reliance upon a single test. The question whether the samples were, or were not, representative of the bulk, does not enter into the argument, for no tests have been compared with each other except those made upon the same sample. Nor have special sets of tests been selected. Those we have dealt with have been taken absolutely at random, and obtained from trustworthy sources, so that the results may be regarded as typical of the uncertainty as regards the calorific value of coal which now exists. The only conclusion one can draw from them as regards calorific value is that it is unsafe to rely upon any statement of the calorific value of a given sample of coal within a margin of about 5 per cent. We mean by this that two independent observers cannot be relied on to agree more closely than this. The same observer, using the same apparatus will usually get results agreeing within one-half of 1 per cent., but nothing like this consistency will be found if portions of the same sample are tested in different laboratories.

The tests referred to in Tables I, II and III are all cases in which different analysts have examined portions of the same samples of coal. If the portions tested were identical in composition, as they were supposed to have been, the variation in the results obtained can only be attributed either to errors on the part of the observer, or to errors inherent in the apparatus. To what cause the errors are due it is impossible to say. In Table IV

TABLE IV.—*Maximum Percentage Variation from Mean Value.*

| — | 3 Tests. Table I. | 3 Tests. Table II | 2 Tests. Table III | 2 Tests. Table III |
|---|---|---|---|---|
| Moisture, per cent. .. | 5·03 | 24·2 | 2·60 | 6·16 |
| Ash, per cent. .. .. | 3·79 | 6·36 | 0·79 | 0 |
| "As fired" value, B.Th.U. .. .. | 1·42 | 4·92 | 0·74 | 1·88 |

we show a comparison between the various results. Taking the mean value in each series of tests as the correct value, which is the only legitimate assumption to make, we find errors amounting to 24 per cent. in the case of moisture, and to nearly 5 per cent. in the case of the calorific value are to be found even in the small number of tests considered. The conclusion to which the figures point is that there is very considerable uncertainty as to the accuracy of the result of any particular calorific test. This uncertainty may be expressed numerically by computing the "probable error" of any observation, as defined above. We have seen that the Fuel Research Board appear to regard 25 B.Th.U. as the probable error of an individual observer using a calorimeter under the most favourable conditions. This error is equivalent to 0·21 per cent. on a true calorific value of 12,000 B.Th.U. We have, in the tests we are considering, ten observations of calorific values, and if from these, the probable error of a single test result is calculated, it will be found to be 1·56 per cent. This figure differs considerably from that of the Fuel Research Board, but we cannot help it. The data we have considered have been commercially accurate calorimeter tests, and from them it appears that any calorific value taken at random is just as likely to be more than 1·56 per cent. out as it is to be within this degree of accuracy. Otherwise expressed, it would appear that if a sample of coal is tested for calorific value by standard methods, it is an even chance that the result will differ from the true value by more than 1·56 per cent.

(*To be continued.*)

## U.S.A. RAILWAY STATISTICS.

A NOTABLE feature of administration in the United States is the great volume of statistical information that it produces. Some branches of this, such, for instance, as its Census of Production, appear with astonishingly little lag behind the events they record. But for the most part it is inevitable that the collection of vast masses of statistics must take considerable time, especially in the normal conditions of official production, and, as happens in other countries as well, figures often do not appear till change of circumstances has deprived them of more than historical interest. A notable example of a body of American statistics that appears with remarkable little loss of time is the collection of railway statistics prepared annually by Mr. Slason Thompson for the Bureau of Railway News and Statistics, of Chicago, not only with the co-operation of the railway companies, but also with assistance from the State and Federal authorities, who administer a system of which his criticism is constant and candid. The 21st issue of this volume has now been published, purporting to cover the year ending December 31, 1923, and collated with the official reports for 1922, and recent statistics

# HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

FIG. 54. THE FOREBAY AND INTAKES.

of foreign railways. Figures are indeed sometimes given for the first six months of 1924.

The year under notice has been, of course, exceptionally prosperous, though the figures for the first six months of 1924 are quoted to show the sort of fluctuation that may occur even in prosperous times. From the point of view of the railways, however, the fly in the ointment to which most attention is drawn—for Mr. Thompson's statistics, though based often on official figures and almost invariably on first-hand returns, form the very substantial skeleton of a continuous and independent criticism of the progress they measure and record—is the nature and extent of Government interference in railway administration. One of the chief interests of this convenient compilation, centres, however, in the collation of the American 1923 figures with those of previous years, and sometimes with figures for foreign countries. The present stage in the evolution of the United States railway system is, indeed, particularly appropriate to the consideration of the figures by which its progress may be measured, for so far as concerns the growth of its roads it appears for the time being to have reached the end of the enormous expansion it underwent during the last half-century. It has now about a quarter of a million miles of road, as it had in 1914, the additional lines constructed since then having been rather less than the mileage—about 7,000, in the last seven years—abandoned, and in some instances torn up, as unprofitable.* Fifty years ago it was rather more than three times as large as the systems of Great Britain; but whereas British lines are now about half as large again as they were then, the United States system has increased nearly five-fold, and is now about ten times the size of the British system. Both systems are now of about the same length as they were ten years ago.

Apart from the gross length of the two systems, the figures that disclose the use which has been made of the respective roads are interesting. At present about a mile of track serves 5 square miles and 2,000 inhabitants in Great Britain, as against 12 square miles and 450 inhabitants in the United States. It carries nearly five times as much passenger traffic (passenger miles) in Great Britain as it does in America, but only one-half to one-third as much goods traffic (ton-miles). The average American passenger journey is, however, three to four times as long as the British, with a demand for carriages that presumably is in some sort of proportion less, for the British systems have not quite half as many carriages again as the American to accommodate their 25 per cent. larger number of passengers. Similarly, the average American haul for freight is between three and four times that usual here, while in 1923 the American tonnage moved was nearly five times as large as the British. The American systems, however, used about three times as many wagons as the British, and this measure of wagon accommodation, which on mere numbers of wagons seems somewhat more favourable to American than to British goods traffic, must, in fact, be far more favourable than it seems in this comparison owing to the difference between the average capacity of the American wagons—about 43 tons—and that of the British.

In spite of the considerably greater disproportion of tonnage, the American systems had less than three times as many locomotives as the British; but this fact is referred not to deficient provision but to the great increase in their weight and tractive power. In 1923, for instance, the total number of locomotives was less than twice what it was thirty years ago, but their total weight was more than four times as great, showing that on the average each locomotive now weighs more than double what a locomotive weighed then. The need for increases of this magnitude arose from the extraordinary growth of the traffic. The population of the country is greater now by about 80 per cent. than it was thirty years ago, and the number of passengers has indeed increased in a somewhat less proportion, though the number of passenger-miles is between two and three times as great as it was. But the growth of goods traffic, which now yields some 70 per cent. of the railway revenue, is out of all proportion larger; three to four times the tonnage, and four to five times the ton-mileage. The passenger stock has increased in a slightly less proportion than the population and slightly greater than the number of passengers carried; but the freight cars, like the locomotives, have provided the required accommodation as much by increase in size as in numbers, for though the systems now have rather more than twice the number of cars they had thirty years ago, the aggregate capacity is over four times as great. That this provision has not been excessive is due to the wide fluctuations of the freight traffic; a decrease, for instance, of about 25 per cent. ton-miles in 1921 was followed by an increase of 11 per cent. in 1922 and another of 22 per cent. in 1923. The net outcome to the American public does not seem specially attractive in passenger rates; just over 3 cents a mile, against 2·66 for this country and just over half a cent for India. In freight rates, however, in spite of some expenses resulting from State regulations, which Mr. Thompson suggests are avoidable, the rate in 1923 worked out at 1¼ cent per ton-mile, against about three times as much in this country and about ¾ cent in India.

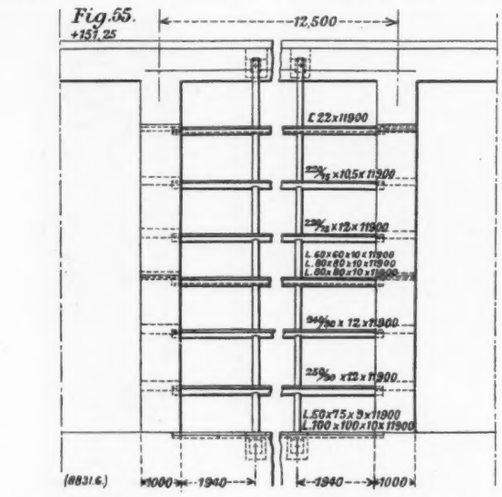
* This slight difference, however, is rather more than balanced by increases in auxiliary and yard tracks and in sidings.

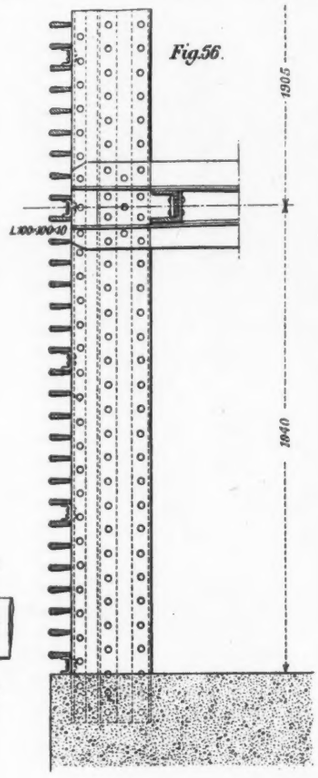
## HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

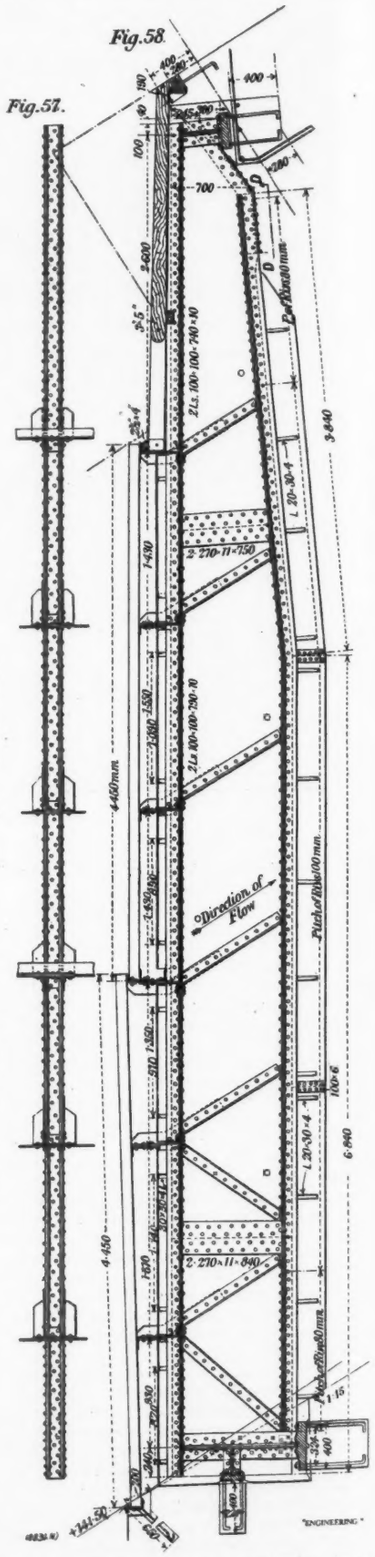
(*Continued from page* 10.)

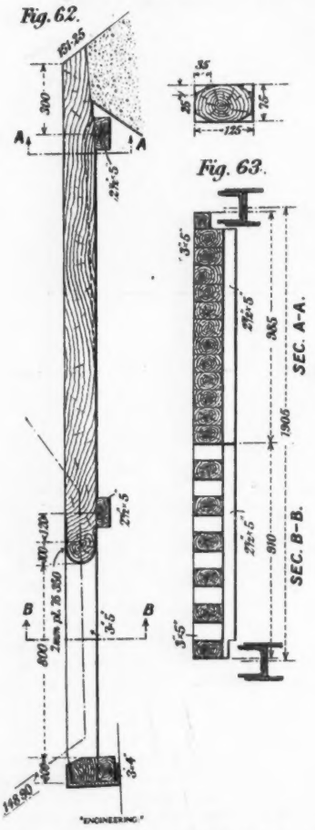
THE power station, as shown in Figs. 1 to 4, Plate I, which accompanied our issue of January 2, is constructed as an extension of the dam itself. It is designed for three generating units, and the turbines of these are supplied through short intakes.

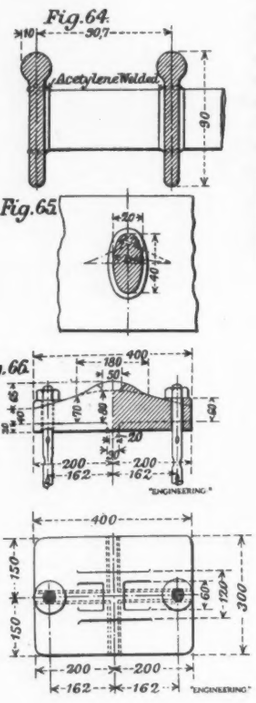
# TRASH RACKS FOR HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

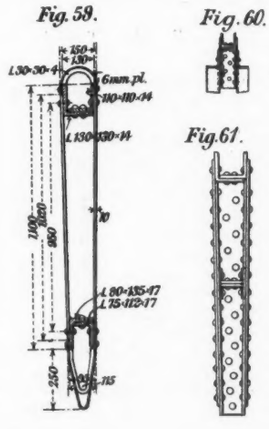


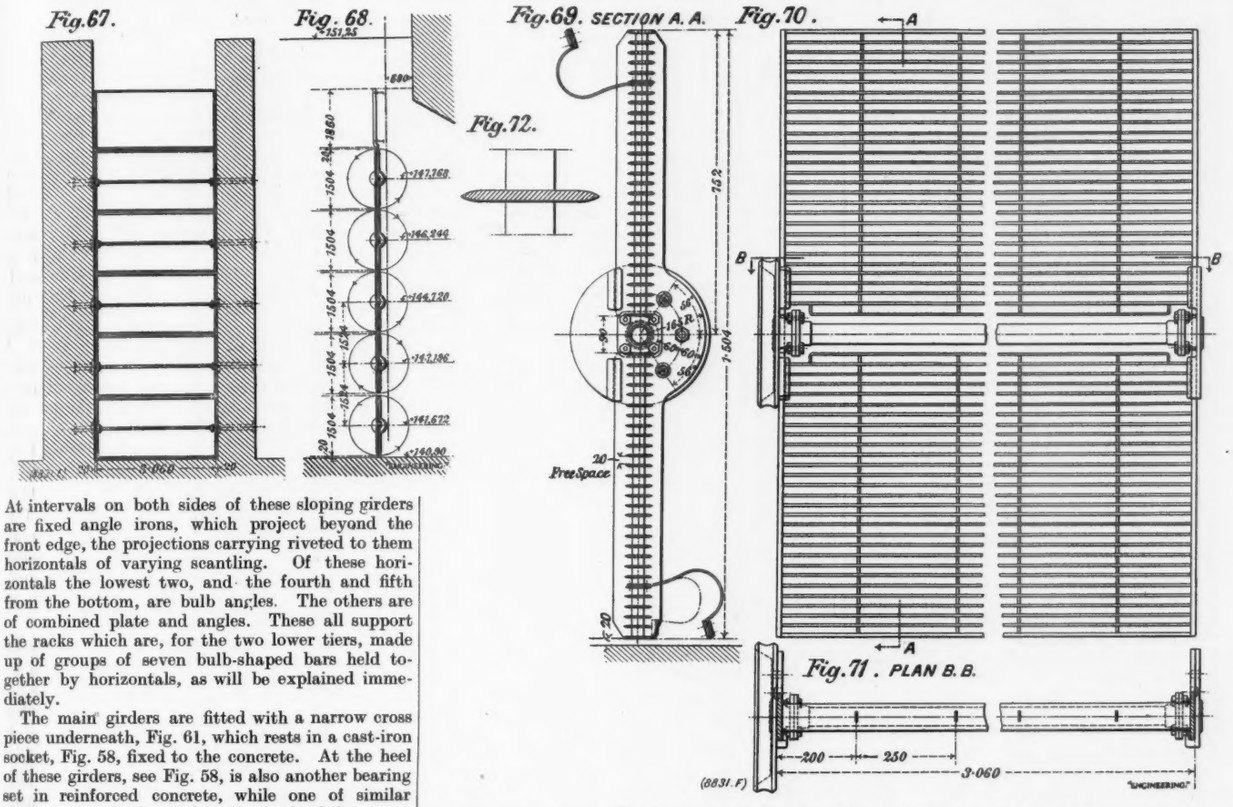




The whole structure is founded upon solid rock. The substructure embodying the turbine scrolls and draft tubes is of reinforced concrete. Concrete is also employed for the construction of the intakes, of which a general view, taken during the process of erection, is given in Fig. 54, page 95. This view shows the forebay and the three intakes. The main openings are divided into three by vertical partition walls, as will be evident from the view just referred to, and also on reference to the small plan reproduced in Fig. 4, Plate I.

In front of the intake to each turbine are strong trash racks to prevent heavy logs and blocks of ice entering the intakes. In addition, in front of the turbines, fish screens are also arranged in accordance with the requirements of Swedish law. Details of the heavy trash racks are given in Figs. 55 to 66, above. These racks are set at an angle of about 57 deg. to the horizontal. They consist of bulb-shaped bars supported by horizontal girders, which in turn are bedded into the concrete at both ends and further supported by a number of sloping main girders. Fig. 55 shows the arrangement of one of the intakes. There are five main sloping girders spaced 1,905 mm. (6 ft. 3 in.) apart, the centre of the outside ones being 1,940 mm. (6 ft. 4·4 in.) from the side walls. The two main partitions between the three intakes are 1 m. (39·36 in.) thick. The main girders are illustrated in Figs. 57 to 61. Of these Fig. 58 gives a side elevation, Fig. 57 showing the front elevation. Fig. 60 is a plan of the top end, while Fig. 61 represents the underside of the bottom end. A typical cross section is given in Fig. 59, from which it will be seen that these girders consist of two over-lapping angle irons at the front and two at the back, riveted one over the other and connected by side plates 10 mm. (0·4 in.) in thickness. The front edge or cutwater is finished with a rounded plate, 6 mm. thick, carried by light angles, and the back edge is also finished off by a projecting taper, 250 mm. (9·8 in.) long, to give good streamline form. The girders have a length of about 11·3 m. (37 ft.). They taper from the top depth, front to back, from 700 mm. (27·6 in.) to 1,100 mm. (43·3 in.), excluding the rounded front and taper back pieces.

# FISH SCREENS FOR HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.




At intervals on both sides of these sloping girders are fixed angle irons, which project beyond the front edge, the projections carrying riveted to them horizontals of varying scantling. Of these horizontals the lowest two, and the fourth and fifth from the bottom, are bulb angles. The others are of combined plate and angles. These all support the racks which are, for the two lower tiers, made up of groups of seven bulb-shaped bars held together by horizontals, as will be explained immediately.

The main girders are fitted with a narrow cross piece underneath, Fig. 61, which rests in a cast-iron socket, Fig. 58, fixed to the concrete. At the heel of these girders, see Fig. 58, is also another bearing set in reinforced concrete, while one of similar character is also located at the back of the upper end. A typical socket is shown in Fig. 66. Each space between the main girders is divided into three, as shown on the plan, Fig. 56, by small channels riveted to the horizontals. Between these channels are placed the trash racks themselves. As already stated, these consist of groups of seven bars, the bulb-shaped section shown in Fig. 64 being actually adopted in lieu of the plain tapered form shown in Fig. 56. These bulb-shaped bars are 4,450 mm. (14 ft. 7·2 in.) long, and are fixed together, spaced 90·7 mm. (43·8 in.) apart, by means of seven horizontals of oval section, as shown in Fig. 65. The bulb bars and crossbars are welded together by the acetylene process. The bottom set of racks rests in a footstep angle iron let into and fixed to the concrete of the sill. The upper end of this set is supported by the third horizontal from the bottom, composed of plate and angle. An angle iron on the upper side of this forms a ledge in which the bottom of the upper tier of racks is placed, the top end of these being backed by a horizontal channel which again supports the third tier. The latter consists of movable shutters of 3-in. by 5-in. timbers. For the lower part, alternate timbers are omitted, thus forming a grid. This will be clear from Fig. 62 and cross-sections, Fig. 63.

The free space between the trash rack bars is 70 mm. (2·76 in.), and the free area amounts to about 65 per cent. of the total surface of the intake area.

The fish screens are illustrated in Figs. 67 to 72. They consist of five revolving screens and one fixed screen to each opening, each intake being at the point where these screens are placed, divided vertically into three, as already explained. The revolving screens work on horizontal axes. Each section has a height of 1,504 mm. (4 ft. 11 in.) and a length of 3,060 mm. (10 ft. 0·5 in.), as shown in Figs. 67 and 68. The grids are shown in greater detail in Figs. 69, 70 and 71. They are composed of a number of thin horizontal bars with tapered edges, as shown in Fig. 72. The flat horizontals are of 5 mm. by 70 mm. (0·2 in. by 2·76 in.) section, welded at the ends to flat bars of 12 mm. by 120 mm. (0·47 in. by 4·72 in.) section. The latter are fastened to a shaft consisting of 2-in. pipe, pivoting in sockets arranged in the side walls of the intake chamber. At one end of each shaft is fitted a self-locking worm gear, each set of five worms being on a single vertical shaft carried up to an operating platform above, where a hand wheel and indicator are fitted for operating the screens and showing their position. All screens of a set are operated simultaneously, but in alternating directions, by the worm-shaft. The horizontal bars of the screens are correctly spaced and the screens strengthened by eight cross-bars to a screen. These bars are 7 mm. by 25 mm. in section (0·28 in. by 0·98 in.), and are passed through holes in the horizontals and fixed to them by electric arc and acetylene welding. The bottom sections are fitted on the horizontal edges with spring fenders, as shown in Fig. 69. These sweep the sill clear of any deposit as the screen is revolved, and thus prevent risk of jamming.

The rack is designed for a difference of water levels of 2 m. (6½ ft.). The top of the highest revolving section is 1·5 m. (5 ft.) below normal water level. Above this section is a fixed screen of vertical iron bars. The weight of the screen works out at 25·6 lb. per square foot of surface.

*(To be continued.)*

## LITERATURE.

*Modern Practical Joinery. A Comprehensive Treatise on the Practice of Joiner's Work by Hand and Machine.* By GEORGE ELLIS. Fifth edition, revised and enlarged. London: B. T. Batsford, Limited. [Price 2*l.* 5*s.* net.]

THE second edition of this now standard work, reprinted from the first, appeared in 1904. It contained 379 pages. The present edition has over 500 pages. In respect, too, of the subject-matter, this marks a very great advance on its predecessor of 20 years ago. A sign of changing conditions is the large space now devoted to the employment of machinery for the preliminary preparation of materials. The growing demands for artistic shop fronts, fittings and show cases are responsible for large extensions of the chapters devoted to these, while domestic fitments, church work and some advanced problems in workshop geometry are introduced. The chapter devoted to timbers is considerably extended. As the work has grown in bulk, and in price, it is now also issued in three separate self-contained volumes to suit those who may wish to possess a particular portion, but are not prepared to purchase the complete treatise. The first volume deals with drawing, tools, workshop practice and processes, joints and machines. The second treats of constructive joinery and fittings for houses and for special buildings. The third deals with new methods, foreman's work, stairbuilding, and timbers.

It is a remarkable work, covering an immense field, and elucidated with upwards of 1,400 illustrations, including 20 double-page and 41 photographic plates. The line drawings are exceptionally clear and complete, and being to a sufficiently large scale, and dimensioned where necessary, they are self-explanatory to a craftsman. Descriptions are lucid, written in plain language, and are not tedious. An advantage of a bulky volume is that the hampering condensation that is necessary in low-priced text-books is a condition not imposed on the writer. Instead we have an amplitude of treatment which ranges from the elementary knowledge that must be offered to the beginner to explanations of the highly elaborated constructions of the craftsman.

The work commences with an account of tools and appliances, illustrated with outlines in perspective, and sectional drawings, these sections being prefatory to the later chapters. Chapter IV on workshop practice describes in very full detail the elementary operations of sawing, planing, morticing, dovetailing and marking out. A number of excellent perspective drawings and photographs elucidate the text. In the next chapter, illustrations are given of the universal steel square, which, with its adjustable fence and graduations, can be used for obtaining any angles required in roof pitches, and the lengths and cuts of rafters

and braces. Angles representing the sides of various polygons are engraved on one blade. A large number of the applications of this valuable tool are shown.

A chapter that will interest engineers is that on joinery machines. It embraces all the standard designs in general service, commencing with the saws and concluding with the sanders. It reveals a marvellous wealth of machinery now at the service of the woodworker, and available for work which was mainly done by hand when some of us were apprentices. One of the remarkable developments is that of horizontal band sawing machines. These are more rapid in action than the circular saw, and waste much less material, while they are from three to five times more rapid than log frame and reciprocating saws. The author is opposed to the operation of machines with unskilled labour. He says that a competent joiner-machinist will turn out better work than the average labourer, since he will, by his special knowledge of the requirements of the work in hand, often utilise a machine in a manner never dreamed of by the unmechanical operator.

This is the view held by a highly-skilled craftsman, but it is not one generally accepted in the engineer's machine shop, where an intelligent operator soon learns the idiosyncracies of the machine which he tends, and contrives to get the best possible results out of it. As mass production grows, and work is more minutely subdivided, the value of the trained mechanic inevitably lessens. Taking an extreme case, Henry Ford has said that 95 per cent. of the men whom he employs are unskilled—men who learn their duties within from two days to a week. In that direction all present-day competitive manufacture is tending. The wealth of machines now employed by woodworkers is enormous. They are ubiquitous not only in big joinery establishments, but in the great railway carriage and wagon shops. They are commonly belted from below, with a system of pneumatic exhaust tubes to carry away the chips and dust. They represent a special trade, however, and few engineers have more than a slight knowledge of their construction, and the work done by them.

Chapter VII, following that describing the machines takes up the methods of their use. A large number of useful outline drawings illustrate many stages in the work of sawing and planing, and that of producing mouldings with revolving cutters. The subject is carried a stage farther in the next chapter, on the preparation of the work. A comprehensive chapter on joints, very fully illustrated, follows. The drawings are mostly in perspective arranged in pages, with figure numbers to each. This completes the matter included in Vol. I of the separate publications, and comprises 168 pages. It is an introduction of an elementary character to the advanced sections on actual constructions in joinery.

Chapters X to XIII deal with doors, frames, linings, windows and their fittings, shutters and blinds. A very large collection of drawings, many of which occupy folding plates are a pleasing feature. Much more than the common everyday types are included. Everything that is required in mansions and hospitals is shown, such as fireproof doors and their frames, windows and shutters of every kind, and many other of the production which makes the highest demands on the skill of the joiner.

The lavish expenditure incurred by tradesmen in the rebuilding of tastefully designed shop fronts is obvious. This is now a lucrative department of joinery. A chapter is given to this, illustrated with many working drawings on folding plates of fronts actually constructed. Then follow descriptions of airtight showcases and methods of setting out curved parts with the best dispositions of timber grain. Then in Chapter XVI come bank fittings, counters, drawers, museum cases, book-cases, church work, pulpits and their staircases, illustrated with working drawings and photographs. A chapter treats of the preparation of curved outlines, those which are thin being formed by steaming and bending; and those of more substantial sections, by building up, marking out and cutting. Splayed and bevelled work follow, and miscellaneous fittings, such as over-mantels, chimney pieces, kitchen fittings, pantry and sanitary fittings. Chapter XX deals with the intricacies of stairmaking and landings. Mouldings occupy Chapter XXI, with methods of setting out and fitting, and tracery panels. The foreman's work is described, and the methods of fixing work. After this, much space is devoted to the woods employed, and the volume concludes with a lengthy glossary, and an index.

Perusing this book with interest, one's thoughts revert to the period when handicraft dominated, and when the making of a panelled door was considered a good day's work for a man, and when all mouldings were produced with hand planes. Now, doors and window sashes are machine-made, sawing and planing are done with machines, mouldings are stuck with revolving cutters, mortices, tenons and dovetails are machine-cut, and sandpapering machines smooth. Yet the work of the skilled joiner has not been deeply invaded, nor the need of apprenticeship lessened, as has appeared to be the case in some other industries, such as the machine shop, concerned with the lighter repetition manufacture. All the high-class constructional work described in this book demands the skill of the experienced craftsman, who is only indebted to the machines for the preparatory and more laborious work. He must fit and fix and finish as of old, for mass production and interchangeability of parts have no place in individual constructions.

The book is one of the most thorough we know. It reflects the highest credit on the Author, who writes *con amore*, and on the publisher. No more welcome present than this could be given to a joiner's apprentice. Things have changed since the old days, when ambitious young men had to gather knowledge slowly, and with much disheartenment. The elder men who knew, were secretive. The craft was something of a mystery reminiscent of mediæval times, and many men, working in grooves never became adepts in the higher grades of constructive joinery. It is possible to get a good idea of the technicalities of the craft from a study of this book. And the engineer, whose work lies in the preparation of specifications and estimates that may bring him into contact with joinery, and the union of timbers, will find much that is helpful as well as of interest in it.

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*Optical Measuring Instruments: Their Construction, Theory and Use.* By L. C. MARTIN, F.R.A.S., D.Sc. London: Blackie and Son, Limited. [Price 17*s.* 6*d.* net.]

THE writer who sets out to deal in a single volume in the manner most useful both to the student, the professional worker, and, so far as may be possible, to the manufacturer, with the vast field of design covered by the term "optical measuring instruments," is confronted by many formidable difficulties. The problem is not only one of selections of class and type adequately to illustrate principles applied in manufacture, but is intimately concerned with errors and methods of use, and with mechanical parts or accessories which combine to affect measurement. The task may be likened to that of the production of a general topographical map of the salient features of a large and complicated piece of country in a single day. Dr. Martin has in his work adopted the only possible course in such circumstances and has flown over the field, produced a series of aero-photographs, and compiled them into a map. He opens his flight with a chapter on the general principles of design, steers across the difficult region of field instruments in six chapters, devotes another six to laboratory instruments, and lands on dry ground with a chapter on the theory of errors, which, incidentally, hardly seems concerned with the systematic errors of instruments. He has done this feat with great skill and ability, his aero-photographs are for the most part remarkably clear, and he has undoubtedly produced a map of salient features which will be of great value to the teacher and student, and of interest and use to many professional workers.

He will probably, however, be the first to agree that the work has the defects attaching to its merits, and that the aero-photographic method, though exceedingly useful if well under control, is no substitute for more laborious regular methods. To take the point of view of a surveyor, who, despite the inevitable or artificial restrictions of scope of the work, looks at the blanks and blurs of outline which to him are of much interest or importance. He would regret that a telescopic alidade having a telescope fitted with stadia lines (but which does not transit), a vertical arc and a bubble, as used with the plane-table, has not been described in Chapter II on "optical pointers," together with simple adjustments; and that, in Chapters III and V, he can obtain little information as to the best practical systems of illuminating the fields of the microscopes of his theodolite, both on the horizontal and vertical circle, by day or night.

He will, however, welcome the excellent discussion in Chapter IV on the divided circle, not to be found in ordinary text-books, will be pleased in the succeeding chapter to find a practical test for obliquity of axes described, and will probably go a good deal further than the author does on p. 73 by saying that cylindrical axes as at present manufactured lead to large variations between angles read on different settings of the plate, and are from his experience unsuitable for instruments intended for measurement of horizontal angles, more particularly in a climate of extremes.

Reflecting upon how his new instrument after the greatest care in adjustment had given beautiful readings to half a second of arc on the microscope heads and had yet shown 45 seconds of difference in reading, of the same angle on different settings of the arc, he will wonder why his mentors have not paid more attention in theory and manufacture to the principle of proportional representation in error between the parts, either optical or mechanical.

Can the venerable subject of theodolites be dismissed without dealing with such matters as clamps, systems of support of the levelling screws or of attachment to the tripod stand, in which Continental practice differs largely from British? His experience would probably lead him to think that the system of support by ball or ogival headed screws in V-shaped grooves becomes more unsatisfactory in wear with heavier classes of instrument, especially where, as in astronomical work, a sensitive bubble and rigidity of support are essential factors. The principle of a ring support for each levelling screw, exemplified in the extreme case of a German design by levelling screws which terminate in hollow cones resting on a flat plate, thus seem to him worthy of attention in such a work.

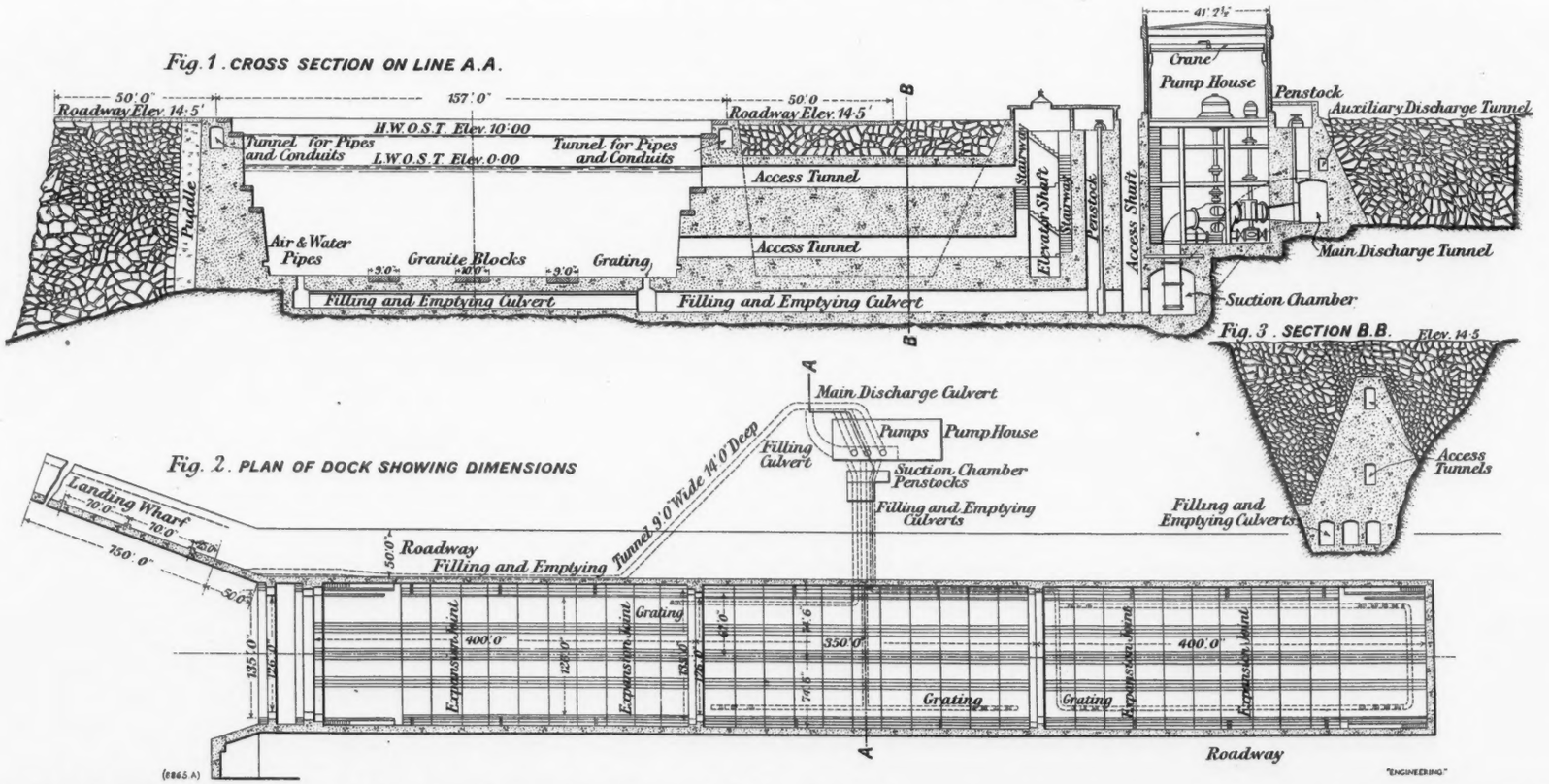
Our surveyor would welcome the useful remarks on tacheometers and anallatic systems in Chapter V, would not agree that systems of internal focussing are sufficiently reliable in manufacture for accurate tacheometry, and would regret the absence of a description of a tacheometer which automatically corrects to the horizontal an observation at any angle of elevation. Might he not also even expect that a reference, say in the section on possible directions of advance in design, would be found to optical instruments or apparatus used in the interesting departure of map-making by aero-photography, a method from which we have just stolen a metaphor?

But with regard to the author's remarks in the fifth paragraph of the preface is there not some unconscious distortion in perspective due to "tilt" of his machine over certain quarters of the field under review?

It may be necessary to give prominence to actual photographs of the wares of particular makers, or advisable to quote their own descriptions of such, or even to insert their remarks on parallax and its adjustment, long stereotyped in every text-book (*vide* Chapters III and VII), although this is open to doubt. But to follow the same lead into an unsound method, as is done in the section in Chapter VI on the adjustment of the horizontal cross-wire of a level, is disquieting. The readings of a level on two vertical staves whose feet are at the same level but one of which is distant 10 yards and the other 120 yards from the instrument will not normally be the same owing to atmospheric refraction, a phenomenon of fundamental importance to all methods of levelling or determination of heights by optical instruments. That the author makes no mention of this important fact in the final paragraph of the same chapter is not reassuring, and is perhaps an example of the danger of concentration upon

THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.

# THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.




purely instrumental sources of error to which the method of treatment is liable.

The illustration (Fig. 49) in this section is not lettered, and in some other cases in the book correspondence between diagrams and text might be improved. Otherwise the illustrations are ample and excellent, and the text very clear and well-arranged.

The chapter on range-finders is interesting and admirable, and in the six following chapters, which traverse the great field of laboratory instruments, while the less specialised readers would welcome further amplification for their own benefit from the same pen, the selection appears good and the principles of construction and use ably described and illustrated.

It will be reflected that here the conditions and methods of use are in reality narrower and more under control, and that with the wide concentration of scientific education and manufacturing effort on apparatus of the kind there is less divorce of the user, so that the salient features of the field are more amenable to treatment. The result will be of the greatest use to a wide class of professional teacher and worker.

The outer cover of the book appeals with justification to many and varied professional men, but in commending it to such it has here been thought necessary to call attention at some length to the particular drawbacks which attend any rapid method in the region which concerns the field engineer and surveyor. An addition of about 25 per cent. to the space devoted to this part of the work would effect an enormous increase in value, and it may not be too much to hope that if a second edition becomes possible, the whole work could be amplified and divided into two volumes, one of which would deal rather more comprehensively with field instruments, free from too strict a definition, and from the fear of occasionally annoying the professional text-book writer, or, worse still perhaps, of offending the manufacturer.

## THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, B.C.

In our issue of September 26 last (page 449) we gave an article describing the new dry dock being built by the Canadian Government at Skinner's Cove, in the harbour of Esquimalt, British Columbia. We reproduced, by the courtesy of the Canadian Authorities, very complete drawings of this dock at that time, illustrating the description by means of plans, sections, and details of the lay-out and design. The dock will form a very notable addition to the facilities on the Pacific Coast, as its usable length is 1,150 ft., width of entrance at coping level 135 ft., and depth over sill at high tide 40 ft. It will thus accommodate vessels of the largest class likely to navigate the Pacific for many years to come, while by means of caisson stops it will be possible to subdivide the length into sections of 400 ft., 350 ft., and 400 ft., or, of course, two of 750 ft. and 400 ft. length respectively.

We are now able to supplement in certain directions the information contained in our previous article, and in Figs. 1 to 13 above, and on pages 100 and 101, and Plate VI, give further illustrations, mainly relating to the pumping installation. The section Fig. 1, above, is taken at the pumping station, on the line AA of Fig. 2. The latter is similar to the plan given with our former article, showing, however, certain slight differences in the arrangement of the filling and emptying tunnel, elevator shaft, &c., these having been re-arranged in a way which has necessitated, we believe, rather less excavation in rock.

Two comparatively recent views (November 4, 1924) of the dock itself are given in Figs. 4 and 5, Plate VI. The first of these was taken from the head of the dock, looking towards the cofferdam behind which the work has been carried out. Fig. 5 is taken from the entrance, looking towards the head. On the right may be seen the commencement of the short wing wall on this side. The

pump-house is set well back from the dock-side and is connected to it by three low-level culverts. These are shown side by side in Fig. 2 and in section in Fig. 3. The pump-house site was excavated in solid rock, and the connection to the dock itself is also cut through rock. A very good view of this excavation was given in Fig. 31, page 449, of our last volume. Fig. 6, Plate VI, is a later view of the same part of the work, this having been taken at the end of May last year. The three subsequent illustrations show the work at later stages, the view in Fig. 7 having been taken on September 4, while the two given in Figs. 8 and 9 were as the work stood on November 4 last. In the foreground in Figs. 6, 7, and 8 is the monolithic substructure of the pump-house. Beyond this in Fig. 7, and on the near side of the pump-house in Fig. 9, may be seen the structure enclosing the shafts, and the culvert connection to the dock. The latter, as seen in Fig. 3, takes the form of a thick wall with steeply battered sides placed in a trench cut in the rock, the trench being subsequently filled in to road level. The wall contains, in addition to the three low-level culverts, two access tunnels shown in the section, Fig. 1, connecting the dock with an elevator and stair-shaft. To the rear of this shaft is a chamber containing the suction penstocks, with again an access shaft immediately behind this. The suction chamber is arranged beneath the pump-house on the side nearest the dock, the pumps delivering into branches leading off on the far side of the structure and combining into one main discharge culvert 9 ft. wide by 14 ft. deep, leading to the sea. A by-pass for filling leads from the latter direct to the pump-suction chamber, and is controlled by a 12 ft. by 7 ft. penstock. The shuttering for the access and penstock shafts, suction chamber, and main suctions is shown in place in Fig. 6. A view of the interior of the pump well is given in Fig. 13, page 101. This shows two of the openings for the main pump suctions, and the three delivery branch outlets leading to the main filling and emptying culvert.

Details of the pump-house are given in Figs. 10 to 12 on this page and opposite, in which the points just referred to will be discerned. The main operation of emptying the dock is performed by means of three vertical-spindle centrifugal pumps driven direct by induction motors of 1,000 h.p. each. One pump is connected to each section of the lock, but the arrangement is such that any one can be employed for any section or all can discharge together, there being one main suction chamber from which all three pumps draw. The main pumps are being supplied by Messrs. Gwynnes Engineering Company, Limited, Hammersmith Iron Works, London. Each pump is of the twin parallel type, with 60-in. suction branch and breeches pipe on the delivery combining to a discharge of 54 in. diameter. The casing is of cast-iron, each pump being arranged on a cast-iron stool acting as a base. The impeller is of cast-iron of the double-inlet type, with shrouded vanes, the whole being balanced and trued up on the shaft, machined externally and finished internally by sand blasting. Gun-metal eye rings and shaft sleeves are fitted. Intermediate shafting, carried in two bearings, connects up with the motor, mounted on the pump-house floor on a cast-iron stool containing a Michell thrust bearing for the support of the shaft. The 1,000-h.p. motors driving these pumps are synchronous machines, wound for 2,300 volts between phases. These and the other electrical equipment are manufactured by the Canadian Westinghouse Company, of Hamilton, Ontario.

In addition to the three main pumps, there are two auxiliary pumps for drainage purposes. These are shown to the right of Figs. 10 and 11, annexed. They are Gwynnes vertical spindle centrifugals, with 22-in. suctions drawing from about 10 ft. lower than the main dock pumps. While utilising the same suction chamber, the part where these pumps are installed is excavated as a sump with a floor about 6 ft. below that of the main chamber. These pumps are designed with side covers to facilitate dismantling and inspection without breaking pipe joints. As regards the class of construction, the pumps are similar to the main pumps, having

# PUMPING PLANT AT ESQUIMALT DRY DOCK.

*Fig. 10.*

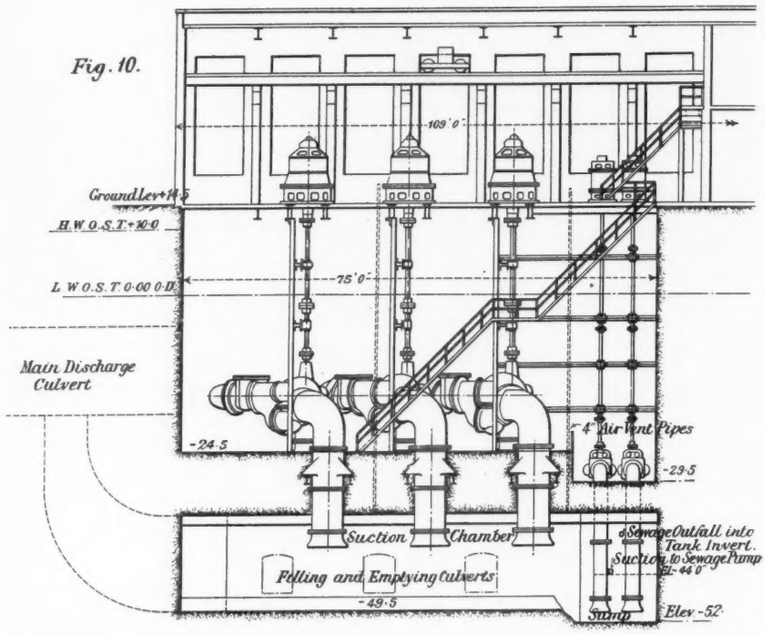
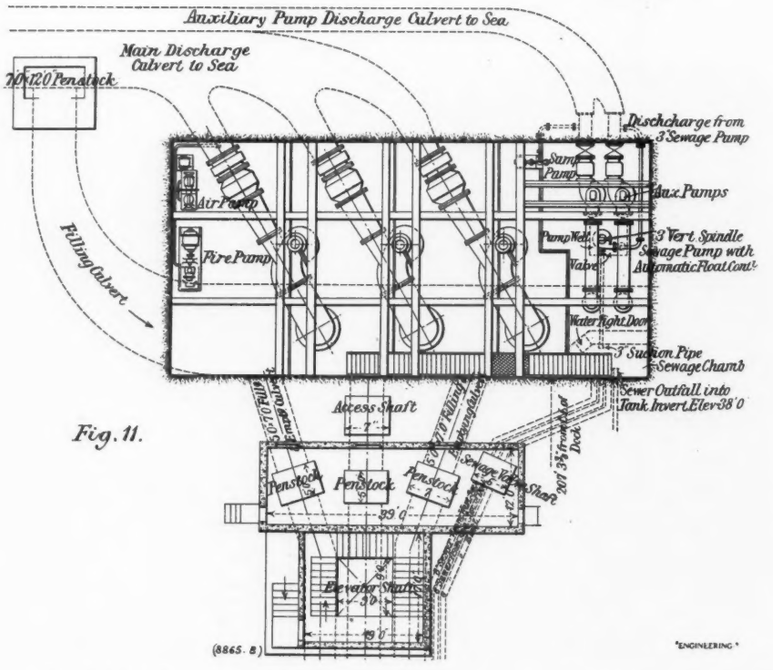



*Fig. 11.*




cast-iron shrouded impellers, gun-metal eye rings and sleeves, Michell bearings for the vertical shaft to the motor above, &c.

An account was given in our previous article of the special arrangements provided for ensuring sanitary conditions in the dock when occupied. A special system of sewers is laid in the floor, with manholes over which portable latrines may be placed, or to which may be coupled chutes from a vessel's side. In the plan, Fig. 11, will be seen three sets of drains passing through a sewage valve shaft into an enclosed tank occupying a corner of the main suction chamber. A 4-in. suction pipe leads from this tank to a well, shown in dotted lines to the left of the main sump in Fig. 12. In this well is placed a 3-in. vertical-spindle Invincible pump by Messrs. Gwynnes, with casing of cast-iron and impeller of gun-metal, the spindle being of manganese bronze. The pump is fitted with an automatic float control gear, being as in the other cases electrically driven by a motor at the pump-house floor level. The delivery of the sewage pump is led into the auxiliary pump discharge culvert. The latter rises to a level considerably above the main filling and emptying culvert, as indicated in Fig. 12.

There are two other pumps in the pump house, both being by Messrs. Gwynnes Engineering Company, Limited. They are shown in Fig. 11. One is for fire service, while the other is an air pump for charging the main, auxiliary, and fire pumps. The fire pump is a two-stage turbo centrifugal pump, with 7-in. suction and delivery branches, mounted on the same bedplate as the motor, which drives it through a leather-bushed pin flexible coupling. The casing is of cast-iron and the impellers are of gun-

# PUMPING PLANT AT THE ESQUIMALT DRY DOCK.

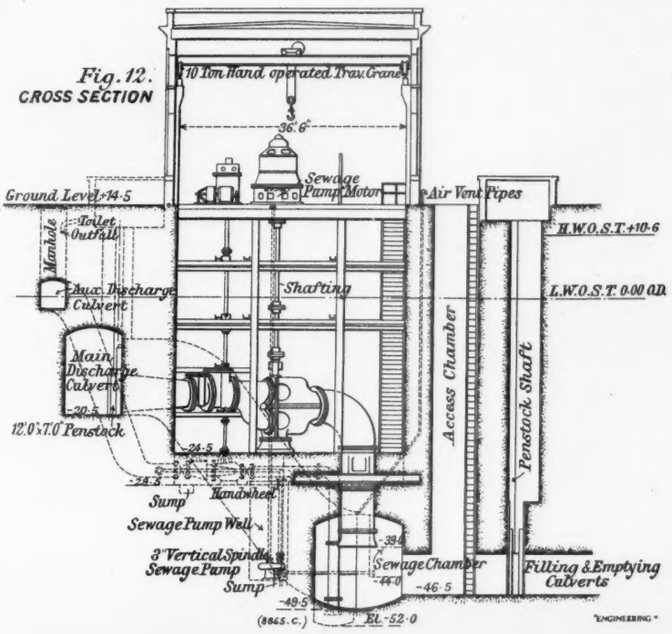


FIG. 13. VIEW OF INTERIOR OF PUMP WELL, SHOWING POSITION OF SUCTION AND DELIVERY CONNECTIONS.

metal, the steel shaft being enclosed by the bosses of the impellers and renewable bronze sleeves passing through the stuffing boxes. The shaft is carried by independent ring-oiled bearings. Renewable liners are fitted to the delivery cover and diaphragm between the stages.

The exhauster pump is of the vertical two-throw type, with single-acting plungers, 12 in. in diameter by 8 in. stroke. The pump is provided with cast-iron barrels with gun-metal liners, and cast-iron buckets. The glands are bushed with gun-metal. Gun-metal Kinghorn valves are fitted. The connections are so arranged that any pump can be charged separately, or any or all together. This pump is driven through reduction gearing by a motor running at 1,160 r.p.m.

Reflux valves of the multiple-door type and penstocks are fitted to the main units, and single-flap reflux valves to the auxiliary pumps. 54-in. valves are provided on the delivery side of the main pumps, electrically operated, as in the case of the large penstocks. The three main pumps, operating simultaneously, are guaranteed to empty the dock in three hours, and to show under these conditions an efficiency of not less than 82 per cent. The penstocks and valves are being supplied by Messrs. J. Blakeborough and Sons, Limited, Brighouse, Yorkshire. The main contractors for the electrical equipment pumping machinery, as well as the pump house, &c., are Messrs. Hodgson, King and Marble, of Vancouver.

The pump house itself is a rectangular structure of reinforced concrete, measuring about 111 ft. long by just over 41 ft. wide. It is of very simple and dignified design, the sides and ends being provided with large lights, separated by pilasters reaching to the cornice. The forms and shuttering for these may be seen in Figs. 8 and 9, Plate VI, in course of erection. One end is fitted with a double door. The interior is arranged for a 10-ton overhead crane, running on a track 20 ft. above floor level.

The power supply is obtained from the British Columbia Electric Railway Company, Limited, from their Jordan River Power Development. Current is received at 60,000 volts and is transformed down at the pump house to 2,300 volts, this voltage being used by the main pump motors, as already mentioned. For the smaller pumps driven by squirrel-cage motors, further step-down transformers provide for current at 500 volts.

## THE SOUTHAMPTON FLOATING DOCK.*

By ERNEST HINKLY SALMON, D.Sc., M.Inst.C.E.

THIS dock was built to the order of the Southern Railway Company by Sir W. G. Armstrong, Whitworth and Co., Limited, from the designs of Messrs. Clark and Standfield. It is the largest yet constructed, having a lifting power of 60,000 tons in sea water. It is 960 ft. long, 170 ft. wide overall, and 70 ft. 6 in. high overall. The clear width is 130 ft. 8 in., and the normal maximum draught of water over keel-blocks is 38 ft. The estimated weight of the dock was 18,990 tons. From measured displacements of the finished dock its actual weight was found to be 19,330 tons, and its net lifting power 60,980 tons. The contract price of the dock delivered at Southampton was 375,000*l.*, exclusive of a number of fittings added subsequently, the shore work, and the preparation of the site. The machinery was specified to lift a vessel of 52,500 tons displacement, and a mean draught of 32 ft. 9 in. in four hours. The transverse stability of the dock is such that, when lifting a ship displacing 60,000 tons, and with her centre of gravity at 44 ft. above the keel, the metacentric height at the critical point is 5·2 ft.

*Construction.*—The dock is so arranged that all the main dimensions are multiples of a unit pitch of 3 in. The plates were drilled in batches of five, or rack-punched. Wherever possible, the frames were constructed in jigs on the ground, and afterwards lifted in position. This lends itself to repetition work, which can be carried out with great expedition.

The contract was placed on October 13, 1922, and the contract time for delivery was 10 months. The Boilermakers' dispute, which lasted for 7 months, retarded the work, the dock being complete and ready for towing on April 14, 1924. The voyage from Newcastle to Southampton occupied 4 days, the average rate of tow being 4 knots. The dock was formally opened by H.R.H. The Prince of Wales on June 27, 1924, when the S.S. Arundel Castle was lifted. The official ship-lifting trial took place on July 12, 1924, the vessel being the S.S. Olympic, which displaced 46,500 tons, the mean draught being 31 ft. 3 in. The time taken was 3 hours 42 minutes.

*Hull Details.*—The construction of the hull follows the ordinary practice common in floating docks. The pontoon is divided into five compartments transversely, of which the central compartment is an air-space. Each section is also divided longitudinally into two divisions. The joints between the sections are effected by providing a joint-chamber at each end of each section, so constructed that the joint-bolts can be inserted in the dry. The seven sections were built separately, and on coupling up they came together with perfect accuracy.

*Machinery.*—The main pumping-installation consists of fourteen centrifugal pumps situated at the bottom of the side wall, electrically-driven, through vertical shafting, by motors placed on the top deck. The motors, of a total capacity of 1,250 kw., are controlled from the valve-house. A main drain runs from end to end of the dock in each side wall, and compartment pipes branch therefrom into each compartment. Each compartment pipe has its own valve, operated from the valve house. Electrically-driven air-ejectors are fitted, so that should the pumps draw air prematurely it may be exhausted before the pumps lose water. Electrically-driven reciprocating piston pumps are provided on each wall for auxiliary purposes, and centrifugal pumps provide circulating water to the condensers of ships in dock.

Power is supplied from the shore at 480 volts, continuous current. The cables are led to the dock along

* Abstract of a paper to be read before the Institution of Civil Engineers, on Tuesday, January 27, 1925. This dock was fully illustrated and described in our issue of June 20, 1924, page 789 *et seq.*

the most northerly boom. The lighting circuits are at 240 volts, arranged on a three-wire system. In addition to the ordinary fixed lights and portable lamp-clusters, a special arrangement of flood lights is provided for the well of the dock.

*Control.*—The whole control of the dock is concentrated in the valve-house. The pump-motors are controlled from this house by means of a remote-control system, and the compartment valves by means of an electro-pneumatic system. Water-level gauges indicate the depth of water in each compartment, and the usual spirit-levels and gauges are provided. An optical deflection indicator enables the dockmaster to observe the longitudinal deflection, and a complete telephone system connects all the houses on the dock, and also with the shore.

*Fittings.*—For the purpose of centering the ship over the keel-blocks, four pairs of mechanical side-shores are provided, so arranged that the ship is automatically centered between them.

The keel-blocks are of a special type. Three longitudinal oak timbers, each 18 in. square, bedded on short transverse oak planks 2 in. thick, run from end to end of the pontoon, the keel blocks proper being mounted on these. Each block consists of three cast-steel wedges, carrying an elm top block, surmounted by a soft-wood cap. These blocks have successfully carried the great loads which necessarily come upon them. The bilge-blocks are all movable, and are of two types, single-web and double-web. These have mild-steel bases, carrying pitch-pine timbers. The pontoon deck is specially stiffened to carry them.

The dock is equipped with the necessary bollards, roller fenders, and similar fittings, and a small electric capstan is fitted at each of the four corners of the top deck for ranging cables, working the flying gangways, &c. A compressed-air service and fresh-water service are installed, also the usual latrine accommodation. An electric travelling crane is provided on each side wall, capable of lifting 5 tons at a radius of 48 ft., or 2 tons at a radius of 80 ft.; and also a floating crane suitable for use with the dock, and capable of dealing with loads up to 150 tons.

Transversely, the dock is moored by means of four lattice braced booms, each 110 ft. long, connected to the dock at one end and to reinforced-concrete dolphins at the other end by steel universal couplings. Longitudinally, the dock is moored by two 3-in. stud-link cables at each end. Access to the dock is provided at all states of the tide, and in all positions of the dock.

## SOUTHAMPTON FLOATING DOCK: SUBSIDIARY WORKS.*

By FRANCIS ERNEST WENTWORTH-SHEILDS, O.B.E., M.Inst.C.E.

THIS paper describes various incidental works which were required in connection with the installation of the new 60,000-ton floating dock at Southampton. The site selected for the dock was the bay between the north-east corner of the dock estate and the jetty known as the "town quay." This position was chosen partly because it was near to the ocean dock where the large steamers are berthed, and chiefly because it was here possible to connect the dock by means of bridges to the mainland, so that men could walk on board and light articles could be carried on to it without the use of ferries. Nearly one million cubic yards of dredging had to be carried out, as a large part of the site was dry at low water. The dredging was carried down to 60 ft. below L.W.O.S.T., or 73 ft. below H.W.O.S.T. This admits of the dock being sunk to its fullest extent without touching the bottom at any time between high and mean water. The dredged material consisted for the most part of sandy clay and hard fine sand, with occasional veins of hard sandstone rock. The bottom width of the cut was made 200 ft., or 30 ft. wider than the dock itself, and the sides were formed with a 3 to 1 slope. Two bucket-ladder dredgers were employed, one of which was specially built for the work, and has a maximum dredging depth of 76 ft. below low water. It proved to be a very powerful machine, and was able to remove the veins of rock without the use of explosives at its maximum working depth.

The dock is moored transversely by means of four hinged steel booms to four reinforced-concrete dolphins, and in a fore and aft direction by cables and anchor-blocks. The dolphins were designed to resist a lateral push or pull of 250 tons each, and a transverse pull or push of 18 tons. Each dolphin consists of a massive reinforced-concrete slab or cap-block 70 ft. long, 32 ft. wide and 5 ft. thick, resting on 94 reinforced-concrete piles, 44 of which are vertical, the remaining 50 being sloped at 30 deg. with the vertical in all four directions. Above the cap-block is a reinforced-concrete wall, V-shaped on plan, containing a pair of steel anchor-ties, which are attached to a heavy steel casting forming the socket of a crucible pin by which the steel mooring-boom is attached to the dolphin. The cap-block is exposed at low water but submerged at high water, and to indicate its position in the latter circumstances a strong timber fence is built round the four edges of the block and carried above high water. On the northernmost dolphin this fence is replaced by a strong timber platform which forms a pier to carry the footbridges.

The construction of the dolphins was carried out by contract. The piles were moulded at a yard alongside a quay about half a mile away from the site, to which the piles and other materials were conveyed from the yard by barge. In order to unload the piles and place them in position, two large derrick cranes were erected on timber piles, one between each pair of dolphins; each crane could lift 10 tons at a radius of 95 ft., and thus could lift any pile off the barge and place it ready for driving. The pile-driving frames were placed on travelling gantries running on timber pile stages and spanning the width of the cap-block. By this arrangement the pile frame could be easily placed in its proper position for driving any pile. The pile frame itself was a stout steel A-shaped structure; this supported a steel lattice mast 66 ft. long, which was bolted to the frame in a vertical central position for driving the vertical piles, and on one or other of the sloping sides for driving the raking piles. The mast supported the pile and the driving-hammer, which consisted of a single-acting steam cylinder weighing 3 tons. On the first dolphin driving was assisted by means of a water-jet, but this aid was afterwards abandoned as it was found difficult to keep the piles truly in line while using it. No special difficulty was found in driving the raking piles. After all the piles were driven, the cap-blocks were constructed. The formwork involved a special design, since the floor-shuttering had to span nearly the whole width of the cap-block. It was therefore suspended from steel lattice girders, specially made for the work, which rested on the side permanent piles and were afterwards buried in the concrete of the cap-block. The concrete for the block was placed in position as tides permitted, the materials being mixed in a barge alongside and filled into skips which were tipped by the large derrick crane. The same cranes handled the steel reinforcement, the anchor castings, and the superstructure. After the dolphin was completed, some gravel was cast out between the piles in order to stabilise it, and rubble-stone was placed in front of each dolphin to prevent the sloping ground from being fretted away.

The footbridges by which the dock is approached are described in the paper. The footbridge which connects the shore with the northernmost dolphin is formed with N-type lattice girders 97 ft. 6 in. long. The dolphin and the dock are connected by hinged bridges, one of which is built on the boom. The other leads up to the top deck of the dock, and is similar in type to the fixed bridge, except that it is supported on turntables, and at its bottom end on a travelling carriage, so as to admit of the various horizontal and vertical movements of the dock.

The fore and aft moorings consist of 3-in. chain cables secured at their outer ends to 40-ton concrete blocks buried in the river-bed, and at their inner ends to cast-steel cable stoppers riveted to the dock. This arrangement admits of the cables being easily lengthened or shortened, if required. They have been set up in such a way that in normal circumstances with no wind blowing there will be a horizontal tension of 10 tons in each cable; and it is estimated that a 20-lb. wind pressure may increase this tension to 107 tons.

* Abstract of a paper to be read before the Institution of Civil Engineers on Tuesday, January 27, 1925.

# LETTERS TO THE EDITOR.

## THE SUPPLEMENTARY RESERVE.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read your article on "The Supplementary Reserve" which appears in ENGINEERING of the 16th inst. with great interest. Apparently, the writer of it has had some experience of the difficulties which were prevalent in getting the right man into the right place during the war, especially at the beginning.

As one who was in charge of the duties of raising and training a battalion of infantry, the following episodes came to my knowledge.

We trained one officer solidly for over twelve months as an infantry soldier, his services as an engineer having been declined by the R.E.'s. When, on his way to join the unit to which he had been attached, he happened to come across some people who, finding that he was by profession an engineer, and therefore wasted as an infantry officer and seeing that there was urgent need of engineers at the spot where he was to land, after some little difficulty managed to get him transferred to the Royal Engineers, with whom he did very excellent work.

Another man with whom I am acquainted came all the way from Canada, went to the War Office and offered himself as an engineer, either to build works, or run them, but he was told that they had thousands of people offering the same thing. This so disgusted the man in question that he went off and enlisted in the Royal Artillery. After he had been with his unit for some time it was discovered by his officers that he was an engineer by profession, and after some considerable difficulty he was transferred to the R.E.'s, and sent as a sapper to control a large shell factory.

Had such a scheme as that advocated by the writer of your leading article been in operation, the delays in getting round pegs into round holes, instances of which I have given, would have been avoided, not only in the cases mentioned, but in thousands of others.

I am, yours faithfully,

London, January 19, 1925. SON OF A GUN.

## BOILER TESTS.

TO THE EDITOR OF ENGINEERING.

SIR,—In ENGINEERING, January 2, 1925, under the above heading is the result of a boiler test taken at the Neepsend Power Station of the Sheffield Electric Supply Department. I quite agree that the subject is of great importance to station engineers, but I should like to see results of tests taken over much longer periods than 5 hours 50 min. The figure of 84·8 per cent. total overall efficiency is exceptionally good, but I think that over a period of say, 6 months, this figure would be nearer 75 per cent. than 85 per cent.

With regard to the cost of evaporating 1,000 gallons of water, the figure quoted is 7*s.* 8·6*d.*, which is worked out from the evaporation per lb. of coal (from and at 212 deg. F.), which is misleading. This figure, when worked out from the actual evaporation per lb. of coal is 9*s.* 11½*d.*, which puts quite a different light on the matter. The figure of 7*s.* 8·6*d.* means nothing; whereas the figure of 9*s.* 11½*d.* shows an actual cost. I might say that the fuel cost per 1,000 gallons on our own Stirling boiler is below 7*s.* 8·6*d.* based on the actual evaporation per lb. of fuel.

Yours faithfully,

W. M. HEBBLETHWAITE.

Huddersfield. January 13, 1925.

## LONDON TRAFFIC.

TO THE EDITOR OF ENGINEERING.

SIR,—May I be permitted to make a suggestion not embodied in the article on "London Traffic," page 78 of ENGINEERING, January 16, 1925?

It is very simple, and could be put into effect immediately without any expense; also it is already employed to advantage in Sydney, where, also, one-way traffic is in vogue, *e.g.*, Pitt- and Castlereagh-streets.

At present, buses stop just beyond the stream of traffic going at right angles; often, because of the crossing line of traffic, they also have to stop on the near side. If a general rule were made that all public conveyances should stop for passengers on the near instead of the far side, it would help considerably in lessening the congestion and consequently in speeding up the traffic.

Yours faithfully,

M. E. DAY.

184, Anerley-road, Anerley, S.E.20.
January 20, 1925.

## THE EXTRUSION DEFECT.

TO THE EDITOR OF ENGINEERING.

SIR,—Much has been heard lately of the so-called "extrusion defect." This defect is reputed to be inherent to bars made by the extrusion process and to consist of a core in the centre of the bar. Parties, perhaps not entirely disinterested, have made use of this alleged defect to recommend metal users to abstain from using bars and sections made by this, the extrusion process, for "fear that such bars might unbeknown to them, be piped or cored!"

To ascertain whether there were any grounds for such apprehensions, three rods, *i.e.*, one of naval brass, one yellow metal and one manganese bronze, made by rolling and three similar rods made by the extrusion process were procured from the usual commercial sources.

Two specimens were cut off each bar and these were sent to one of the leading public testing houses in London for Izod impact tests under identical conditions. The results are given below.

The fractures of the rolled and extruded specimens were so different that photographs of these have been taken and are reproduced in Figs. 1 and 2 herewith.

It is somewhat remarkable that the specimens of

# THE EXTRUSION DEFECT.

FIG. 1.

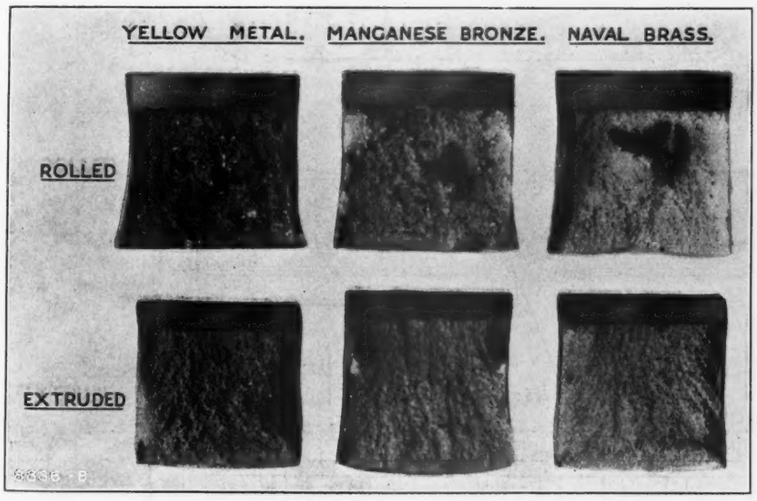



FIG. 2.

extruded rod, which according to rumour should be piped and cored, shows no sign of this, whilst the

*Comparison under Izod Impact Bend Tests of Extruded and Rolled Rods.*

In each case the dimensions of the test pieces were 10 mm. by 10 mm., V-groove included angle 45 per cent., depth 2 mm., and the energy of the Tup was 120 ft.-lb.

| Alloy. | Description. | Energy Absorbed in Foot-Pounds Mean of Two Tests. |
|---|---|---|
| Yellow metal .. | Extruded | 39·6 |
| | Rolled | 23·25 |
| Naval brass .. .. | Extruded | 20·9 |
| | Rolled | 14·25 |
| Manganese bronze .. | Extruded | 25·7 |
| | Rolled | 24 |

rolled rods, show the "extrusion defect" in a very marked manner.

Yours faithfully,
S. W. DEAN.

Catford, S.E., January 15, 1925.

## ENGINEERS OR MECHANICS.

TO THE EDITOR OF ENGINEERING.

SIR,—I constantly see workmen on strike referred to as "engineers" in the daily Press. At one of the meetings of the British Association last year, a speaker gave what seemed to me an excellent definition discriminating between engineers and mechanics. I should be grateful if anyone can repeat it, as I have no record. A "mechanic" does not necessarily originate the design which he carries out. I do not, of course, refer to the definition so often repeated in the volumes of Proceedings, Inst. C.E.

Yours faithfully,
C. H. WINGFIELD.

Brimpton Common, Reading.
January 15, 1925.

## THE WHITWORTH SCHOLARSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—My letter which appeared in your issue of December 19 and in which I adopted, somewhat purposely, the extreme attitude of a certain type of works manager, has called forth so many spirited rejoinders that I trust you will allow me to reply. My position has been misunderstood to a certain extent, chiefly because I had tried to be very brief. I cannot understand, for instance, how your correspondents can tax me with contempt for study, which is the one thing I think essential above all others, and without which, evidently, no one could attain my criterion of "contributing to the advance of knowledge."

My point was plainly stated: A degree, *per se*, is of little or no value (in a non-academic career) if it is one's only qualification (this was even in italics). If one has other qualifications, which show originality of thought and ability to obtain and assimilate and make use of knowledge, the degree is superfluous, a mere coat of varnish. "H. H. W." hit the nail on the head: "grit" is what is wanted, but, while agreeing with him that the example he mentions shows such a dose of this quality as one would like to meet more often, yet it does not show that the obtainment of a degree is in itself evidence of "grit" at all!

To "Interested" I will say that a graduate of 19 can give no guarantee whatever that he can do anything else but study on lines laid down for him, usually with the help of a tutor. If, however, instead of obtaining a degree, he has given evidence of original thought, there is an almost dead certainty that he will develop this essential quality. Both "H. H. W." and "Interested" make me say what I never meant; they mix up study for the sake of knowledge in the pursuit of some purpose useful to others besides oneself and the process of being taken through a course of study for the purpose of passing an examination. The two are widely different, and cannot be done simultaneously; moreover, while any one who can do the first can evidently go successfully through the second, many who succeed in the second fail utterly in the first; hence the latter is the better test!

Of course, I only discredited academic distinction as an end in itself; 19 out of 20 students believe that, once the coveted distinction is obtained, they have done with study! If a young man would not only realise that he must be prepared to study all his life, but actually look forward to it, he would be worth much more, both to others and to himself. The remaining one out of the 20 gets his degree *en passant*, as a matter of routine; to him it is but an incident in a life crowded with captivating work. It is *he* who writes the books on my shelves, not the others! If a man has produced a book which, even in part only, is good, he clearly falls into the right category, according to my criterion. If he be a graduate, his degree is but accidental to a personality which would make itself felt anyhow, and a whole alphabet after his name will add nothing to his stature. I buy a book when, on examining it carefully, I find that some of it is good; the name of the author only comes in because, if the book is good, I like to know who wrote it.

As to the knowledge I have "condescended to receive at the hands of graduates," it has been very flimsy; I wanted more than a skeleton to pick for examination purpose. I was trained in one of the best known technical colleges in London, and was, in order of merit, at the top of the list of diploma awards. My lecture notes were a mere patchwork without continuity of link. Very often, it was only after spending a week on the subject of a lecture of one hour's duration, extracting all the information from every book I could find access to, and welding the lot into a kind of monograph on the subject, that I could say that I had learned as much as I could digest for the time being. (But I had not learned it from the lecture!) To this patchwork fashion of dealing out knowledge, I owe the failure to get the first job I applied for. Incredible as it may appear, electric traction had been left out of the pattern of patches constituting the course of electrical engineering; I could not answer a very simple question put to me by the head of the firm, and "the other man" got in. He was probably the better man, and I hope he got on well! The works were of high repute, and it was the chance of a life-time. Since that experience I have framed my courses of study myself!

To say that I expect a graduate to be a perfect and infallible engineer is an unwaranted exaggeration. I made clear that I would prefer a man who, beside his practical training, shows sign of intelligent understanding and close study of some of the aspects of his profession at any rate, and of being able to extract from books and assimilate whatever knowledge he lacks. I would want something else than a diploma, and if the something is there I would not care a straw if the diploma was absent.

My most recent experience is that of a young science graduate who, in a specification for an electrical instrument, used the words "conductor" and "dielectric" as if they were synonymous, and stated that "the electric pressure is led into the terminals of the apparatus." It proved impossible to make him see that this phraseology was, to say the least of it, undesirably quaint, and, as he strongly resented being corrected, I deemed him to be past redeeming. Another case which came under my experience is that of a Whitworth Scholar whose idea of preparing an exercise paper for beginners in algebra was to write at random all the exercises of the same kind which came to his mind, without any regard whatever to gradation, variety, or completeness of treatment of the several cases possible; all the teachers under him were compelled by him to set to their unfortunate students this most appalling piece of dispiriting and ineffective drudgery. To my knowledge, this man had never contributed in the slightest degree to the progress or spreading of knowledge (except by teaching, which

# COMBINED CRANKLESS GAS ENGINE AND GAS COMPRESSOR.

CONSTRUCTED BY MESSRS. CRANKLESS ENGINES, LIMITED, MELBOURNE, VICTORIA.

(*For Description, see opposite Page.*)

*Fig. 3*

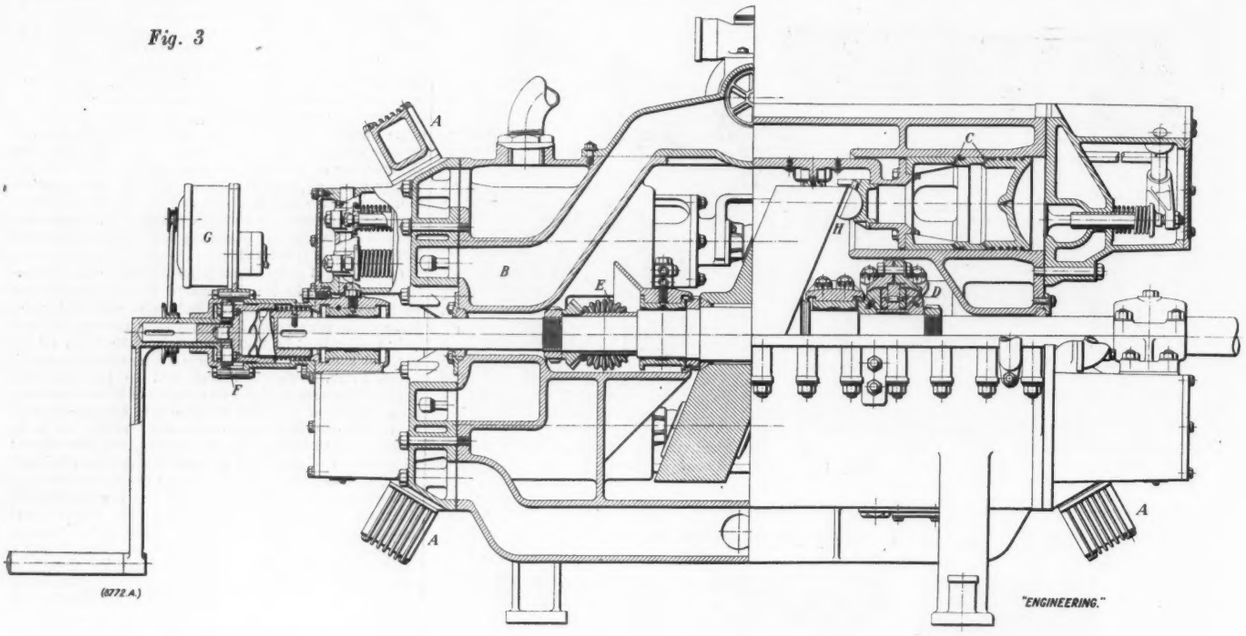
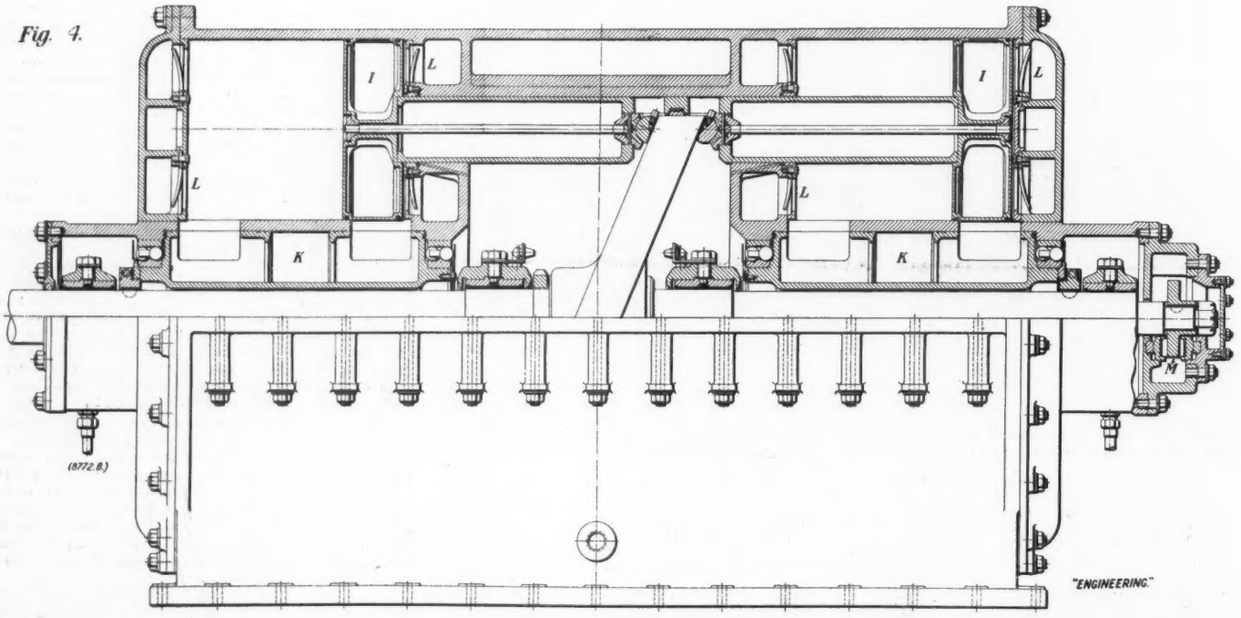



*Fig. 4.*




was his paid occupation). My criterion would have eliminated him.

I admit that I am prejudiced, but my opinion has been forced upon me by what I have seen with my own eyes of the men I have met. Besides, what value is placed on a degree by the very Institutions which confer the distinction? Whenever they advertise a vacancy, they ask for an honours degree (a pass B.Sc. has no chance); moreover, the salary they offer is often quite inadequate. The reason is not far to seek. —they know that to get an Honours degree no particularly rare qualities are necessary, except the time and means required to do the required studies, and that there are men in plenty to choose from. Why should others put a higher value on their products than they do themselves? When educational institutions themselves will offer to graduates a salary greater than that of a tram driver or a dustman, others will follow suit, and the value of academic distinctions will increase accordingly.

The following typical detail bears out Dr. S. P. Thompson's remark as to the use of a degree to an engineer: A certain student left college at the same time as I did, only he was at the lower extreme end of the list, and he had a very narrow escape from being refused altogether the diploma of the college. Ten years later his salary ran to four figures, being more than three times my own! And I was the best student of our year! Personality will always tell in the end. Here was, however, not a man who did not think the diploma of any use, but one who tried hard to get it, and failed! I do not understand the allusion to Sir Frederick Bramwell's feelings. It is a truism that many leaders in their profession would fail if they sat for the examinations one must now pass in order to attain a standard equivalent to theirs. He is a bold man who, being towards the end of his career, would assert that he could again pass the examinations he passed successfully in his youth.

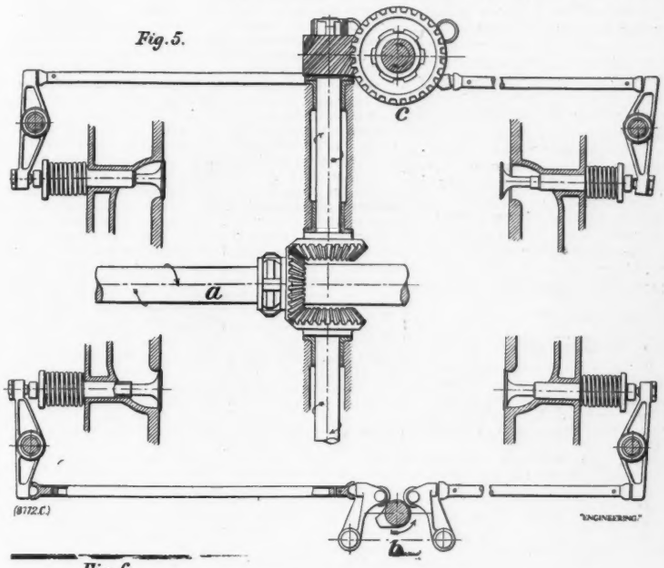
May I now score a point for the other side? I lost my second great chance for the lack of a degree! A few years after leaving college I was approached by the governing body of one of the technical Institutes of London, who suggested that I should apply for the post of principal, which was vacant, and for which they had no satisfactory candidate. I had nothing to show, except a diploma which was not recognised as an equivalent to a degree, and I knew only too well that whatever I was worth would only show when I actually did put my hand to the plough. I did not reflect that since they sought me they might take me with whatever qualifications I had, and I declined the offer! Such opportunities do not come twice.

After that I thought that a degree might be useful,

# COMBINED CRANKLESS GAS ENGINE AND GAS COMPRESSOR.

CONSTRUCTED BY MESSRS. CRANKLESS ENGINES, LIMITED, MELBOURNE, VICTORIA.

*Fig. 5.*



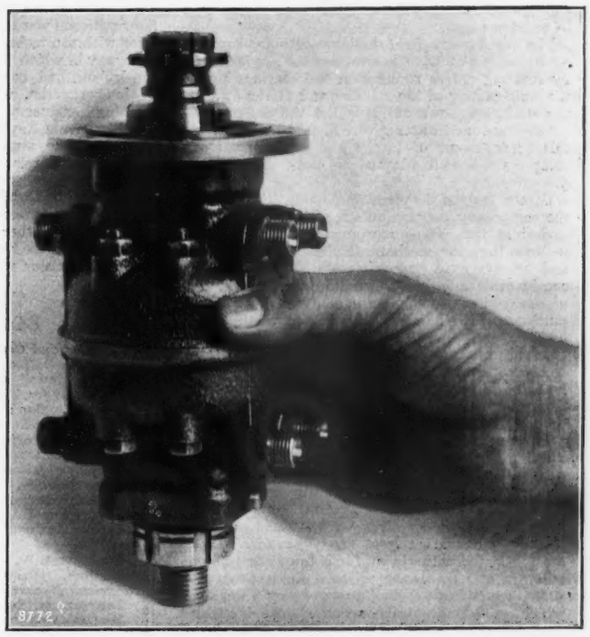
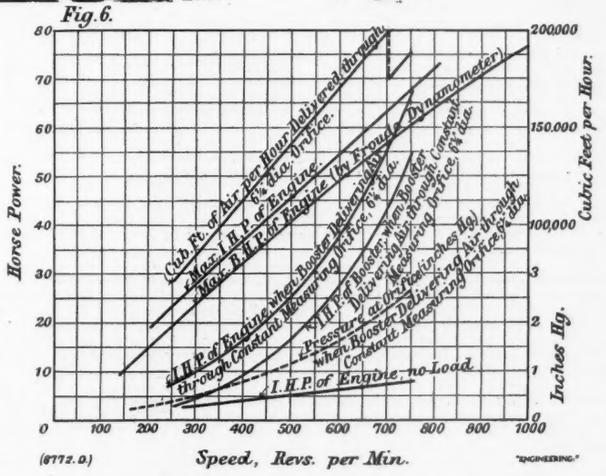




FIG. 7.

*Fig. 6.*


Horse Power.
Cubic Feet per Hour.
Inches Hg.
Speed, Revs. per Min.
(Cub. Ft. of Air per Hour Delivered through 6" dia. Orifice.
Max. I.H.P. of Engine when Booster Delivering through Constant Measuring Orifice, 6" dia.
Max. B.H.P. of Engine (by Brough's Dynamometer)
I.H.P. of Engine when Booster Delivering through Constant Measuring Orifice, 6" dia.
Pressure at Inlet Valves (Inches Hg.) when Booster Delivering through Constant Measuring Orifice, 6" dia.
I.H.P. of Engine no Load
(8772.a)
"ENGINEERING."

*for show*, and I began to work for it by myself. It was too interesting a task; I could not resign myself to leave a subject after merely sketching it in, so to speak. In one case I spent a whole nine weeks' vacation writing what was practically a treatise on a subject represented by four words in that curriculum, which to "H. H. W." appears to be the climax of scientific attainment. To put the curb on my eagerness I then had recourse to a correspondence course to guide and restrain me. I spent half my time arguing with my tutors and, backed by my library, showing them how often the papers I was given fell short of a satisfactory standard. They must have blessed the war, which ended the feud! When it was over, I was too glad to be safely back home again to bother further about conforming to artificial standards which had become of no use to me, so that I can still sign myself,

NOT A B.Sc.

London, January 17, 1925.

## COMBINED CRANKLESS GAS ENGINE AND GAS COMPRESSOR.

WE illustrate on this and the opposite pages, and on page 108, one of two crankless gas engines and compressors supplied to the Australian Gas Light Company of Sydney, N.S.W., by Messrs. Crankless Engines, Limited, of 6, Queen-street, Melbourne, Victoria. The complete unit is shown in Fig. 1, page 108, whilst Fig. 2 is a view of the engine, with the upper half removed. As has already been explained in previous articles in ENGINEERING, this design is due to Mr. A. G. M. Michell, who realised that the principle embodied in his well-known thrust block made it practicable to revive the swash-plate type of prime mover, which had been unsuccessfully experimented with by an earlier generation of mechanics, who were attracted by its simplicity, but whose ingenuity was rendered abortive by enormous frictional losses. With the Michell pads, in which effective lubrication is ensured by rational design, the friction is extraordinarily low, and very large loads can be carried on pads of small dimensions.

A bastard section through the gas engine cylinder of the unit is represented in Fig. 3, opposite. This has eight single-acting cylinders, of which one is shown in section at the right-hand top corner of Fig. 3. The piston for this cylinder is directly connected to a similar piston on the opposite side of the swash-plate, or "slant," to use the term introduced by Mr. Michell. The Michell pad, which transmits the thrust of the piston to this slant, is shown at H, and there is, it will be seen, a spherical joint between this pad and the piston. The motion of this spherical seat is such that oil is drawn in between the opposing surface in much the same way as it was in the case of the bearing with which Tower experimented, and, in fact, on connecting a gauge to the bottom of the cup, it was found that the oil at that point attained a pressure of 900 lb. per square inch. Thoroughly efficient lubrication of this spherical joint is thus ensured automatically in the same way as it is in the case of a journal running in an oil bath. The Michell pad is kept from rotating bodily by a lug which engages with a slot to be seen in the casting in which the cupped recess for the spherical joint is formed.

It will be seen that holes are drilled through the wall of the piston at the scraper rings C. These holes prevent any accumulation of oil pressure between this ring and the gas rings of the piston, such as might cause oil to leak past the latter into the explosion space.

As there are eight cylinders symmetrically distributed, all inertia forces are absolutely balanced, since when the pistons on the upper half are being accelerated towards the right, those at the bottom are receiving an equal acceleration to the left. Though the inertia forces are thus balanced, there is, of course, an inertia moment due to the fact that the two opposing accelerations do not act along the same line. This inertia moment has been most simply but very ingeniously balanced by an appropriate adjustment of the weight of the slant. If the latter be considered as rotating alone, that is with the pistons removed, it is obvious that the centrifugal forces developed by the one-half of the slant, will not be in the same line as those due to the other half. There will thus be a moment on the bearings, and a little consideration will show that this moment is opposite in direction to the moment due to the reaction of the piston accelerations already referred to. Hence by suitably adjusting the relative weights of the piston and slant, absolutely perfect balance is obtained.

The gas supply to the engine enters through a valve at the top of the engine and passes through appropriate ports, such as B, to the inlet valves of the cylinder. One of these valves is shown clearly at the right-hand top corner of Fig. 3. The exhaust valves are of the same type, and the mechanism by which they are operated is shown diagrammatically in Fig. 5, above. In this the main shaft of the engine is represented by *a*. This shaft drives two horizontal shafts by bevel gearing, as indicated. These bevel gears are also shown in place at E in Fig. 3, and are plainly visible in Fig. 2, which also shows clearly the drive for the vertical camshafts. These latter are represented in Fig. 5, at *b* and *c*. The exhaust valves are of the same type as the inlet valves, and the position of the exhaust pipes is indicated in Fig. 3 at A. The cylinder heads and walls are thoroughly water jacketed, water being admitted through the long passage shown at the bottom of the left-hand part of Fig. 3. Axial motion of the main shaft is prevented by the Michell thrust block, shown at D.

In service, ignition is secured by an ordinary high-tension magneto, but a special starting magneto is also fitted. This is shown at G, Fig. 3, and, as will be seen, it is driven by a belt from the starting handle. The engine can easily be started by one man, epicyclic gearing (shown at F, Fig. 3) being fitted in order to reduce the torque on the starting handle. The engine is rated at 50 brake horse-power when running at 750 r.p.m. and supplied with gas of 500 B.Th.U. lower calorific value.

Forced lubrication is provided to all the bearings of both engine and compressor. The oil is distributed by two small crankless oil pumps, one of which is represented in Fig. 7. These give each an independent supply of oil to eight different distributing points. An oil strainer is fitted in an oil tank at the bottom of the engine bedplate.

A section through the compressor is represented in Fig. 4, opposite. This has eight double-acting cylinders

each 9⅜ in. diam. by 8½ in. stroke. At the designed speed of 750 r.p.m. these are rated to deliver 200,000 cub. ft. of gas per hour against a head of 60 in. of water. This is a very high volumetric capacity for a machine of so small a bulk. The discharge per minute is, in fact, about 130 times the total bulk of the machine, and the volumetric efficiency has been found by test to be 96 per cent.

The pistons are light hollow castings, having the section shown at I. The intake of the gas is controlled by rotating valves running on ball bearings housed in the main casting of the machine and driven by a lug on the shaft, as shown at K, whilst the delivery valves are light automatic spring valves, as shown at L. With this arrangement of intake and delivery valves the compressor is well adapted to work against varying pressures.

Careful tests of the plant were made prior to delivery, the compressor running on air. The results are represented in the curves reproduced in Fig. 6. These indicate that the mechanical efficiencies of the engine and booster were approximately 87 per cent. over a considerable range of load, and that the gas consumption of the engine was slightly over ½ per cent. of the air pumped. This figure would be appreciably reduced had the compressor being run on gas, as it will be in actual service.

After about six months of experience with these two machines under actual commercial conditions. the Australian Gas Light Company has placed repeat orders for the similar machines.

In conclusion, reference may be made to a very striking demonstration of the high efficiency of the swash-plate mechanism, due to Mr. W. Stone, who has constructed a model which can be driven by compressed air. This model has a "slant" about 2 in. in diameter, and is so arranged that the angle of the slant can be varied from zero upwards. The pads are lubricated with air, and it is found that the model will run and accelerate up to a final speed of some 30,000 r.p.m. with a slant angle of only ¾ deg., a fact which, no doubt, will appear almost incredible to those who have not seen the model at work.

## ELECTRICAL DEVELOPMENT IN THE IRISH FREE STATE.

THE scheme of hydro-electric development on the River Shannon, which has been prepared for the Free State Government by Messrs. Siemens-Schuckertwerke of Berlin, and on which we commented in our issue of March 14 of last year, has been reported on, and approved of, by a commission of four Continental engineers. The Commission consisted of Mr. Borgquist, chief electrical engineer, of the State of Sweden; Mr. Meyer-Peter, Professor of Hydraulic Engineering, at Zurich; Mr. Norberg Schulz, chief electrical engineer to the State of Norway, and Mr. Rohn, Professor of Constructional Engineering at Zurich. It is reported in *The Statist*, of January 10, that this Commission has strongly recommended the adoption of Messrs. Siemens-Schuckertwerke's scheme, and declaring this to be the sole and proper method of proceeding with electrical development in the Free State. It stated that a partial development of the Shannon could supply the complete needs of the Free State.

Our contemporary gives many interesting particulars in connection with the scheme, which provides for the diversion of the River Shannon, near O'Brien's Bridge in County Clare, and conveying its waters by a canal about six miles and a-half long to Ardnacrusha, about three miles north of Limerick. Here the power-house will be situated, and the water will be led back into the river by a tail race about a mile long. The fall at the power-house will be approximately 100 ft. It is proposed in the first instance to instal three 30,000-h.p. units, which it is considered will meet the present power needs of the Free State of 150 million units per year. It is expected that this supply will be available in a dry year. During this first stage, Lough Derg only is to be used for storage. With the ultimate development of the river, it is proposed that a total of six 30,000-h.p. turbines shall be installed, and an output of 425 million units is anticipated. The scheme covers some improvements in the navigation of the river, and will give all the counties from Cavan to Limerick a direct outlet to the sea without transhipment of produce.

The electrical distribution system is to consist of a network over the complete State, which will supply the majority of towns of over 500 inhabitants. Transmission to Dublin and Cork will be at 100,000 volts, and the main transmission lines for the rest of the country will operate at 35,000 volts. Subsidiary transmission will be at 10,000 volts. Distribution will probably be at 380 volts and pole transformers will be largely used. The estimated cost of generation, after the initial development has been carried out, is 0·42*d.* per unit, and when the full development is completed, 0·25*d.* per unit. The capital cost of the first part of the scheme is 5,200,000*l.*, but this figure includes interest on capital during construction, which is estimated to take three years.

We criticised the whole of the procedure in connection with this scheme in our article of March 14 last, and nothing has transpired since which suggests that our criticism was too severe. Our point was concerned not with the technical details of the scheme, but with the way in which the whole future of electricity supply in Ireland had been handed over to Messrs. Siemens-Schuckertwerke, who are acting as promoters, consulting engineers, and contractors, without competition from anyone. The procedure was protested against very strongly by the Institution of Civil Engineers in Ireland last March, and a reprint of their correspondence with the Ministry of Industry and Commerce in Dublin was given in our issue of May 2. The original agreement left it open for the Free State Government either to operate the scheme themselves or to leave it to Messrs. Siemens-Schuckertwerke to do so. This decision will mark the next stage in the matter.

## BOOKS RECEIVED.

*Motor Car and Coach Painting for Private, Commercial, and Mass Output.* By CHARLES E. OLIVER. London: W. R. Howell and Company. [Price 28*s.* net.]

*Mathematics for Technical Students.* By E. R. VERITY, B.Sc. London: Longmans Green and Company. [Price 12*s.* 6*d.* net.]

*Erdruck auf Stützmauern.* By RICHARD PETERSEN. Berlin: JULIUS SPRINGER. [Price 5·40 gold marks.]

*A Popular History of American Invention.* Vol. I. *Transportation, Communication, and Power.* Vol. II. *Material Resources and Labour-Saving Machines.* By WALDEMAR KAEMPFFERT. New York and London: Charles Scribner's Sons. [Price £3 3*s.* net.]

*The Testing of High Speed Internal Combustion Engines.* By ARTHUR W. JUDGE. London: Chapman and Hall, Limited. [Price 25*s.* net.]

*Electrical Measuring Instruments.* Part II.: *Induction Instruments, Supply Meters and Auxiliary Apparatus.* By C. V. DRYSDALE, D.Sc., M.I.E.E., and A. C. JOLLEY London: Ernest Benn, Limited. [Price 55*s.* net.]

*United States Geological Survey.* Water Supply Paper No. 516. *Surface Water Supply of Hawaii, July* 1, 1919, *to June* 30, 1920. [Price 20 cents.] No. 518. *Ground Water in Musselshell and Golden Valley Counties, Montana.* By A. J. ELLIS and O. E. MEINZER. [Price 20 cents.] No. 520–C. *Power Resources of Snake River between Huntington, Oregon and Lewiston, Idaho.* By W. G. HOYT. No. 535. *Surface Water Supply of Hawaii, July* 1, 1920, *to June* 30, 1921. [Price 15 cents.] Washington: Government Printing Office.

*Fuel. Solid, Liquid and Gaseous.* By J. S. S. BRAME, F.I.C., F.C.S. Third edition. London: Edward Arnold and Co. [Price 18*s.* net.]

*Ce que tout Aviateur doit savoir.* By ANDRÉ LAINE. Paris: Gauthier Villars and Cie. [Price 12 francs.]

*Electrical Technology.* By H. COTTON, M.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.* net.]

*The Rectification of Circular Arcs.* By C. P. HOLST. Leiden: E. J. Brill, Limited.

*The Geometry of the Screw-Propeller.* By C. P. HOLST. Leiden: E. J. Brill, Limited.

*The Connecting Rod and Crank Mechanism and Its Inertia Forces.* By C. P. HOLST. Leiden: E. J. Brill, Limited.

*The Design of Cranes and Hoists. Including the Construction and Design of Details of Lifting Tackle.* By HERMANN WILDA. Second revised edition. London: Scott, Greenwood and Son. [Price 6*s.* net.]

*Automotive Construction and Operation for Automobile Students, Mechanics, &c.* By J. C. WRIGHT and FRED. C. SMITH. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

*Gas Meters: their Construction, Use, Fixing, Inspection, and Maintenance.* By ALBERT T. GILBERT. London: Crosby, Lockwood and Son. [Price 7*s.* 6*d.* net.]

*Les Lignites et leurs Applications Industrielles.* By EDMOND MARCOTTE. Paris: Gauthier Villars and Cie. [Price 20 francs.]

*Statics: Including Hydrostatics and the Elements of the Theory of Elasticity.* By HORACE LAMB, M.A., LL.D., D.Sc. Second edition. Cambridge: University Press. [Price 12*s.* 6*d.* net.]

THE LATE MR. W. H. JOHNS.—We regret to record the death of Mr. W. H. Johns, of "Clearo," Reigate, Surrey, which took place after an operation on January 9. Mr. Johns, who was 54 years of age at the time, was well known to a wide circle of friends particularly in the electrical industry. For many years he filled the position of manager of the instrument department of Messrs. Johnson and Phillips, Limited, of Charlton, with which firm he was associated during the greater part of his professional career, having joined them in 1890, after an apprenticeship served with Messrs. J. Stone and Co., Limited, of Deptford. Even those who were only lightly acquainted with the late Mr. Johns could not fail to be attracted by his personality, and his unexpected death has left a deep sense of loss among his colleagues at Charlton. The funeral took place at Reigate on Tuesday, January 13.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—Since the advent of the New Year it has been generally anticipated that a slight revival would be experienced, but the position compared with a month ago shows little alteration. The call for heavy steel of all descriptions is far from strong, though it is expected that current output will show an increase on that for the corresponding period of last year. One of the busiest sections is that devoted to the manufacture of railway steel, parts and fittings, axles, tyres, wheels and springs. The recent placing of contracts by home railways with local firms has placed these concerns in a much stronger position. With foreign and Colonial transport undertakings developing further, there is every prospect of this district benefiting by the placing of arrears of orders which should keep works operating at greater capacity for many months ahead. Manufacturers of ship steel, marine castings, and turbine parts report patchy conditions. The demand for these products has not yet recovered from the recent slump, and though an improvement has been experienced, the general position continues unsatisfactory. The Midlands are big consumers of automobile steel, motor-car parts and castings, and output from this district is daily expanding. In the implement and machinery branches business is mainly confined to the Colonies, who are also taking road-making and excavating implements in increasing quantities. The tool trades are doing better than for some time past. Though the Dominions are the chief buyers, several other markets are showing a tendency to open out, and before long an improvement should be witnessed. Colliery development in this and adjoining areas is responsible for a substantial call on pit head gear and winding equipment.

*South Yorkshire Coal Trade.*—The position shows an improvement as compared with a week ago, the demand for most classes of fuel being in the ascendant. Best steams continue to go away in substantial tonnage for home consumption, while export requirements are somewhat more active. Cobbles and nuts are finding a better market, with prices showing a rising tendency. Slacks occupy a stronger position. House coal is still disappointing, and collieries are faced with the difficulty of carrying rising surpluses. Foundry and furnace coke are in better request. Quotations:—Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 19*s.* 6*d.* to 23*s.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; rough slacks, 9*s.* 6*d.* to 12*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.—An exhibition of drawings submitted in connection with the recent annual prize awards of the Royal Institute of British Architects will be held at the Galleries, 9, Conduit-street, London, W. 1, from January 20 to February 2, 1925. The principal award, the R.I.B.A. (Alfred Bossom) Studentship, with which are included a gold medal and 250*l.*, was secured by Mr. Frank Edgar Bennett, of 42A, Markham-square, Chelsea, S.W. 3.

TENDERS.—The Department of Overseas Trade, 35, Old Queen-street, London, S.W., announces that tenders are invited by the City of Cape Town, South Africa, for the supply and delivery of a line of 33-in. internal diameter lap-welded, coated, mild-steel pipe. Offers will be received until June 3, 1925, and United Kingdom firms should make theirs through local representatives.—In connection with the construction of the commercial port of Vila Real de Santo Antonio in Southern Portugal, the Department of Overseas Trade informs us that all tenders will be received at Lisbon up till March 21, 1925.—The Municipal Electric Works of Timisoara, Transylvania, are calling for tenders, which will be received up till March 26, 1925, for the supply of a turbo-generator, Scott transformers, high-tension feeders, and various accessories. A deposit of 4 per cent. must accompany each tender. A copy of the specification and general conditions, in French, together with plans, are available for inspection at the Department of Overseas Trade.—Several other calls for tenders have been announced in the past few days by the Department of Overseas Trade, from whom further particulars may be obtained regarding them. In South Africa the municipality of the city of Port Elizabeth are inviting tenders, to be submitted by February 13, 1925, for sewage pumping or ejecting plant.—The State Electric Works at Montevideo, Paraguay, are inviting offers, to be presented by March 9, 1925, for 4,500 m. of assorted galvanised iron water pipes, and also 4,715 fittings for the same, including bends, tees, flanges, nuts, and check valves.—Railway material is wanted by the Administration of the Royal State Railways of Siam, at Bangkok, which call for tenders for steel rails and permanent-way accessories which will be received till May 1, 1925, while offers for the supply of superstructures for steel railway bridges will be received until May 15, 1925.—The Government Water Power Office in Helsingfors, Finland, invites tenders for the supply of materials, &c., for turbine chambers required in connection with the equipment of the hydro-electric plant now being constructed at Imatra. Tenders for these materials must reach Helsingfors by April 1, 1925. A copy of the specification, which is in German, and a series of blue prints will be lent to interested United Kingdom firms on application to the Department of Overseas Trade at the above address.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—Output of Cleveland pig-iron has been enlarged, but production appears to be no more than is needed to meet current requirements, and makers report their stocks much more than fully sold, so that the statistical situation continues quite healthy. Home trade is on a fairly satisfactory scale and fairly good sales are being made to Scotland, but export transactions are few and small, and prospects as regards overseas sales are far from encouraging, comparatively cheap foreign iron being still freely offered in Continental markets. Prices here are, perhaps, a shade easier, but are not quotably lowered—No. 1 being 85*s.*; No. 3 g.m.b., 80*s.*; No. 4 foundry, 79*s.*; and No. 4 forge, 78*s.*

*Hematite.*—The position as regards East Coast hematite is peculiar. Producers have heavy unsold stocks but they are markedly disinclined to make price concessions, and report they are obtaining the rates they are asking. In this branch also transactions are almost entirely confined to sale for home use. Nos. 1, 2, and 3 run from 87*s.* to 87*s.* 6*d.*, and No. 1 is put at 6*d.* above mixed numbers.

*Rekindling of Furnaces.*—Messrs. Bolckow, Vaughan and Co. are rekindling another blast furnace this week, making the second idle furnace to be relighted by that firm and the fourth to be restarted in the district during the past fortnight. This increases the number of furnaces in blast on the north-east coast to 44. In normal times over 70 are kept running.

*Foreign Ore.*—Sales of foreign ore are very little heard of, and it is difficult to ascertain on what terms contracts could be arranged. Sellers still quote on the basis of best rubio at 22*s.* 6*d.* c.i.f. Tees, but would doubtless consider favourably offers on lower terms.

*Blast-furnace Coke.*—Durham blast-furnace coke continues in fairly good request for local use, and good average qualities are selling at round about 24*s.* 6*d.* delivered.

*Manufactured Iron and Steel.*—Contracts for manufactured iron and steel are difficult to arrange. Most producers are keen to book orders. Common iron bars are 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 10*s.*; steel joists 9*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 12*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 17*l.* 10*s.*

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—While no change of any note can be reported in connection with the Scottish steel trade, a fairly good undertone is noticeable and an optimistic spirit prevails. One thing which partly accounts for this is the tendency of Continental prices to firm up still further. Meantime the demand is exceedingly slow, and orders are not being booked to any extent with the result that much plant is not in operation. With no forward move in trade in general since the year commenced the consumers of steel material are not sending out specifications against contracts, and business overall this week is quiet. The export side is not one whit better than it has been during recent months and the inquiry is of a very limited nature. Prices are unchanged and are as follow:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; and sections, 9*l.* 10*s.* per ton, all delivered Glasgow stations.

Active conditions are general in the black sheet trade, and most of the works are well supplied forward, so that a steady run is assured. This applies chiefly to light and galvanised sheets, whereas the heavier gauges are very slow in movement. Fresh inquiries for the former amount to a goodly tonnage, and foreign buyers seem anxious to cover their requirements as the higher price of spelter tends to raise quotations. The latter are as follow:—Sheets, $\frac{3}{16}$ in. to $\frac{1}{4}$ in., 12*l.* per ton, delivered Glasgow station; galvanised sheets, 24 b.g., 18*l.* to 18*l.* 10*s.* per ton, f.o.b. Glasgow.

*Malleable Iron Trade.*—In the West of Scotland malleable-iron trade the conditions have not changed and are of a very hand-to-mouth character. The daily demand is exceedingly disappointing and plant can scarcely be kept running continuously. Inquiries are not just so good this week. The steel re-rolling sections, while not too well employed, are moving moderately well. Prices are steady with "Crown" bars at 12*l.* per ton, delivered Glasgow stations.

*Scottish Pig Iron Trade.*—The producers of Scottish pig-iron are not meeting with much support from buyers at the present time, as specifications are coming along very slowly. New business is still scarce, but deliveries of foundry grades have improved a bit, although really nothing to enthuse over. Prices are maintained at previous levels and are as under:—Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 12*s.* 6*d.* per ton; and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

*Shipments of Scottish Pig-Iron.*—The shipments of Scottish pig-iron from Glasgow Harbour, for the week ending last Saturday, January 17, amounted to 535 tons. Of that total 379 tons went overseas and 156 tons coastwise. For the corresponding week of last year the figures were: 3,136 tons to foreign destinations and 505 tons coastwise, a total shipment of 3,641 tons.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*Welsh Coal Trade in* 1924.—Returns compiled from official statistics by the Cardiff Chamber of Commerce show that the export trade of South Wales suffered a decline of 4,372,871 tons in 1924 when compared with 1923, and were also 526,870 tons less than in 1922. Shipments of coal were reduced by 4,170,121 tons from the ports of Cardiff, Newport, Swansea, and Port Talbot, though the coastwise exports were increased by 64,402 tons, and foreign bunkers by 22,591 tons, but foreign cargo was lowered by 4,257,114 tons. Shipments of coke were only about a third of that exported in 1923, and showed a decline of 212,005 tons, but those of patent fuel were increased by 9,255 tons.

The returns of the shipments from the four leading Welsh ports in the past three years are appended:—

| | 1922. | 1923. | 1924. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Coal— | | | |
| Foreign .. .. | 25,197,637 | 29,487,574 | 25,230,460 |
| Coastwise .. .. | 1,931,672 | 1,585,277 | 1,649,679 |
| Bunkers .. .. | 4,242,307 | 4,030,140 | 4,052,731 |
| | 31,371,616 | 35,102,991 | 30,932,870 |
| Coke .. .. .. | 97,431 | 327,190 | 115,185 |
| Fuel .. .. .. | 1,170,718 | 1,055,585 | 1,064,840 |
| Grand Total .. | 32,639,765 | 36,485,766 | 32,112,895 |

The coal shipments for South Wales in 1924 were as follows:—

| From | Foreign Cargo. | Coastwise Cargo. | Foreign Bunkers. |
|---|---|---|---|
| | Tons. | Tons. | Tons. |
| Cardiff .. .. | 15,631,990 | 1,105,794 | 2,761,889 |
| Newport .. .. | 4,448,989 | 381,625 | 716,011 |
| Swansea .. .. | 2,921,264 | 104,681 | 380,589 |
| Port Talbot .. .. | 2,228,217 | 57,579 | 194,242 |

Exports of coke and patent fuel in 1924 are appended:—

| From | Coke. | Fuel. |
|---|---|---|
| | Tons. | Tons. |
| Cardiff .. .. | 95,128 | 403,508 |
| Newport .. .. | 7,289 | 115,024 |
| Swansea .. .. | 5,657 | 489,852 |
| Port Talbot .. .. | 7,111 | 56,456 |

*Pitwood Imports in* 1924.—As was only to be expected in view of the reduced output of the Welsh collieries in 1924, in consequence of the depressed condition of the foreign export trade the supply of mining timber received from abroad was reduced by 260,349 loads. Importations were lowered at each port with the exception of Llanelly, where the quantity landed was increased from only 1,048 loads in 1923 to 7,761 loads in the past year. The quantity received from France, Portugal, Norway and Sweden, and Newfoundland was lessened, but was increased from the Irish Free State, and Finland and Russia. Altogether, 1,658,956 loads were landed in 1924, of a value of 2,296,828*l.*, or 27*s.* 9*d.* per load, compared with 1,919,305 loads valued at 2,755,448*l.*, or 28*s.* 8*d.* per load in 1923. The volume and value of pitwood and pitprops landed at the different ports were as follows:—

| | 1923. | | | 1924. | | |
|---|---|---|---|---|---|---|
| | Loads. | £ | Per Load. | Loads. | £ | Per Load. |
| | | | *s.* *d.* | | | *s.* *d.* |
| Cardiff .. | 1,215,495 | 1,855,507 | 30 7 | 999,927 | 1,469,227 | 29 7 |
| Newport .. | 389,233 | 485,637 | 25 0 | 345,295 | 428,003 | 24 9 |
| Swansea .. | 130,392 | 171,970 | 26 6 | 128,603 | 173,344 | 27 0 |
| Port Talbot | 183,137 | 240,789 | 26 4 | 177,370 | 216,216 | 24 6 |
| Llanelly .. | 1,048 | 1,545 | 29 6 | 7,761 | 10,038 | 26 0 |
| | 1,919,305 | 2,755,448 | 28 8 | 1,658,956 | 2,296,828 | 27 9 |

TOLLEY'S INCOME-TAX TABLES.—A useful publication to those who wish to have, in convenient form, statements regarding the decisions in leading cases on various points in connection with the taxation of individuals and companies, Tolley's Complete Income Tax has now reached the ninth year of its publication. The main table, in which personal incomes for 1922 to 1925 are dealt with, takes the form of a folded sheet and is left free from the general collection of tables and charts, which are bound together. A handy method of obtaining immediate access to any section required by the user is afforded by the use of different depths for the various folder pages. At the foot of each sheet there is a statement in large letters of the matters included for treatment in that section. It is doubtful whether any publication on the subject has been put into such a convenient form for easy reference. This collection of data is sold with a supplement dealing with the Irish Free State at 3*s.* post free, or separately at 2*s.* 8*d.* post free, from the compiler, Mr. Chas. H. Tolley, 107, Tierney-road, Streatham Hill, S.W. 2. The Irish section may also be obtained separately, for the price is 8*d.*

## NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storey's Gate, S.W.1. General Meeting. Reports to the Cutting Tools Research Committee: "Flow and Rupture of Metals during Cutting," by Mr. Walter Rosenhain, D.Sc., F.R.S., and Mr. A. C. Sturney, B.Sc., and "An Experimental Study of the Forces Exerted on the Surface of a Cutting Tool," by Mr. T. E. Stanton, D.Sc., F.R.S., and Mr. J. H. Hyde. Friday, January 30, at 7 p.m. Informal Meeting. Discussion on "Alternatives to the 'Clash' Type of Change-speed Gear for Motor Vehicles."

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—To-night, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. "A Few Experiments with Shock-Absorbing Hulls for Flying Boats," by Lieut. N. Olechnovitch.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Boiler-house Records and their Practical Value," by Mr. R. H. Parsons. Friday, January 30, at 7.30 p.m., Lecturette, "Notes on High-Voltage Electrical Transmission," by Mr. E. Ambrose.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, January 24, at 7.15 p.m., at the Municipal Technical College, Park-street, Hull. Lecture, "Feed Water Treatment," by Mr. Lewis.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, January 26, at 5.30 p.m., at John-street, E.C.1. "The Properties and Uses of Monel Metal," by Mr. C. A. Packer.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, January 26, at 7 p.m., at Savoy Place, Victoria Embankment, W.C.2. Informal Meeting. Discussion on "The National Physical Laboratory and its Work." Opened by Mr. S. W. Melsom.

THE ROYAL SOCIETY OF ARTS.—Monday, January 26, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lectures: "Radiological Research—A History" (Lecture II), by Mr. V. E. Pullen. Tuesday, January 27, at 4.30 p.m., Dominions and Colonies Section, "Economic Research in Tropical Development," by Mr. Walter R. Dunlop. Wednesday, January 28, at 8 p.m., Ordinary Meeting, "The Electrical Equipment of the London County Hall," by Mr. Charles A. Baker, M.I.E.E.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 27, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Papers to be submitted for discussion: "The Southampton Floating Dock," by Mr. Ernest Hinkly Salmon, D.Sc., M.Inst.C.E. "Southampton Floating Dock: Subsidiary Works," by Mr. Francis Ernest Wentworth-Shields, M.Inst.C.E.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 27, at 7.30 p.m., at 39, Elmbank-crescent, Glasgow. "Straight-Frame Ships," by Dr. A. M. Robb.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, January 27, at 7.30 p.m. at the University, Leeds. Faraday Lecture: "World-Wide Radio Telegraphy," by Professor G. W. O. Howe, D.Sc., M.I.E.E.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 27, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. Discussion on "The Effect of Internal Obstructions on the Performance of a Lighting System," by Mr. J. W. T. Walsh.

THE NEWCOMEN SOCIETY.—Wednesday, January 28, at 5.30 p.m., in Prince Henry's Room, 17, Fleet-street, E.C.4. "Windmills of Cape Cod," by Mr. E. P. Hamilton. "Lighting by Coal Gas in 1765," by Mr. J. Macfarlan. "Some Notes on a Neglected Worthy, John Patison of Airdrie," by Mr. David Brownlie.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, January 28, at 8 p.m., at the Institution of Mechanical Engineers, Storey's Gate, S.W.1. "Studies in Filtration," by Messrs. B. W. Clarke, S. G. M. Ure and J. W. Hinchley.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, January 29, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. "Railway Carriage Bogie Trucks in Service," by Mr. H. Kelway Bamber.

THE INSTITUTION OF WELDING ENGINEERS.—Thursday, January 29, at 8 p.m., at Caxton Hall, Westminster, S.W.1. "The Philosophy of Welding," by Sir W. Peter Rylands, J.P.

THE MANCHESTER ASSOCIATION OF ENGINEERS—Friday, January 30, at the Engineers' Club, Albert Square, Manchester. "Superheat and Superheaters," by Mr. J. R. Hannon.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday January 30, at 9 p.m., at Albemarle-street, W.1. The Evening Discourse will be delivered by Professor John W. Gregory on "The Mountain Structure and Geographical Relations of South-Eastern Asia." Afternoon Lecture. Thursday, January 29, at 5.15 p.m., Sir William Bragg on "The Properties and Structure of Quartz" (Lecture I).

BRAZILIAN COMMERCIAL SECRETARY'S VISIT.—Mr. Ernest Hamblock, Commercial Secretary to His Majesty's Embassy at Rio de Janiero, will shortly pay a visit to the United Kingdom, when he will interview, at the Department of Overseas Trade, British manufacturers and merchants interested in export trade to Brazil. Such interviews will only be given by appointment.

# COMBINED CRANKLESS GAS ENGINE AND GAS COMPRESSOR.

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(*For Description, see Page* 105.)

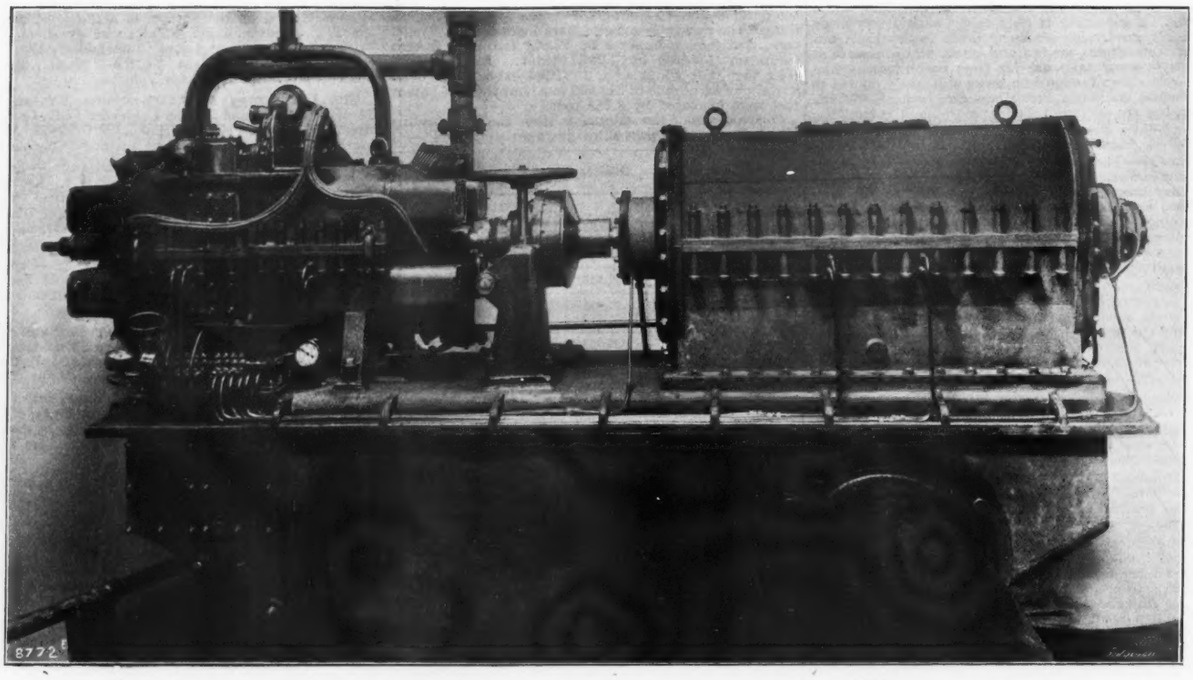

FIG. 1. VIEW OF ENGINE AND COMPRESSOR COMPLETE.

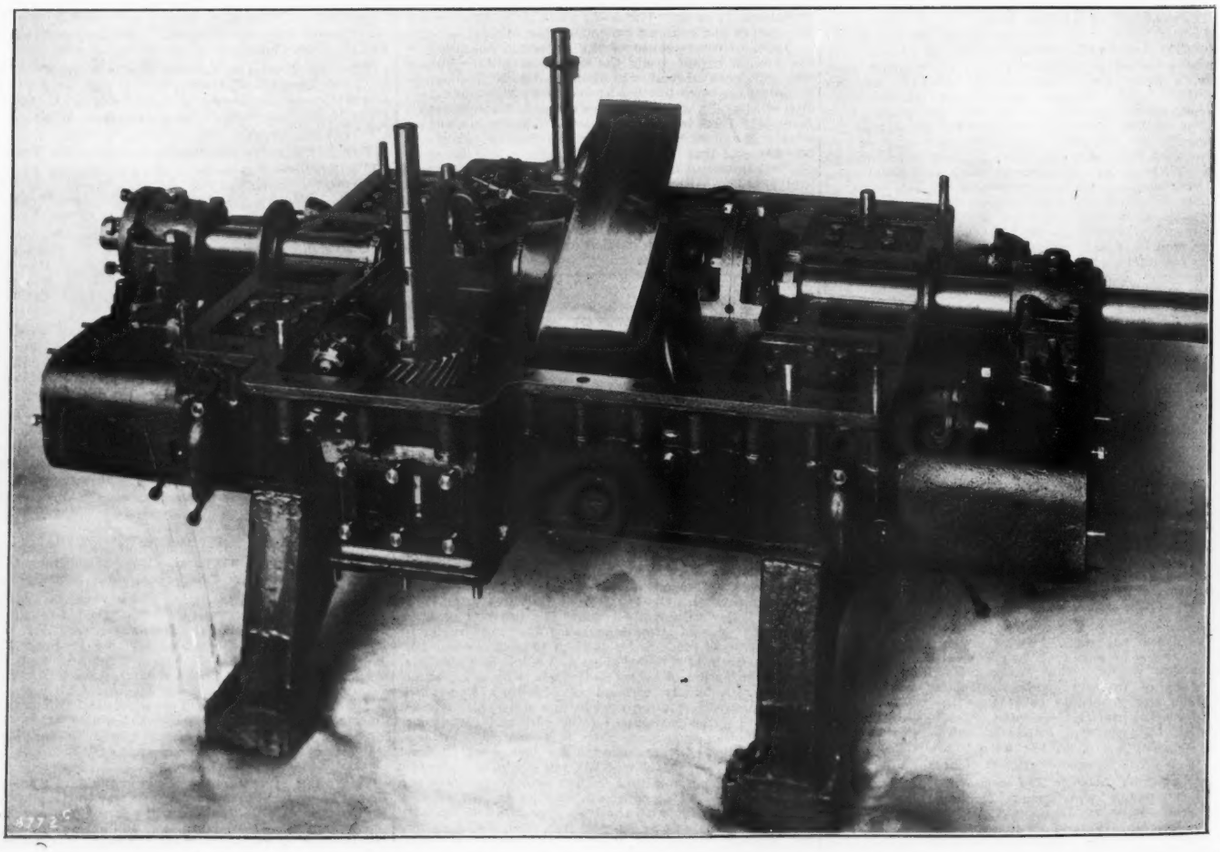

FIG. 2. VIEW OF ENGINE WITH UPPER HALF OF CASING REMOVED.

# THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.

(*For Description, see Page* 99.)

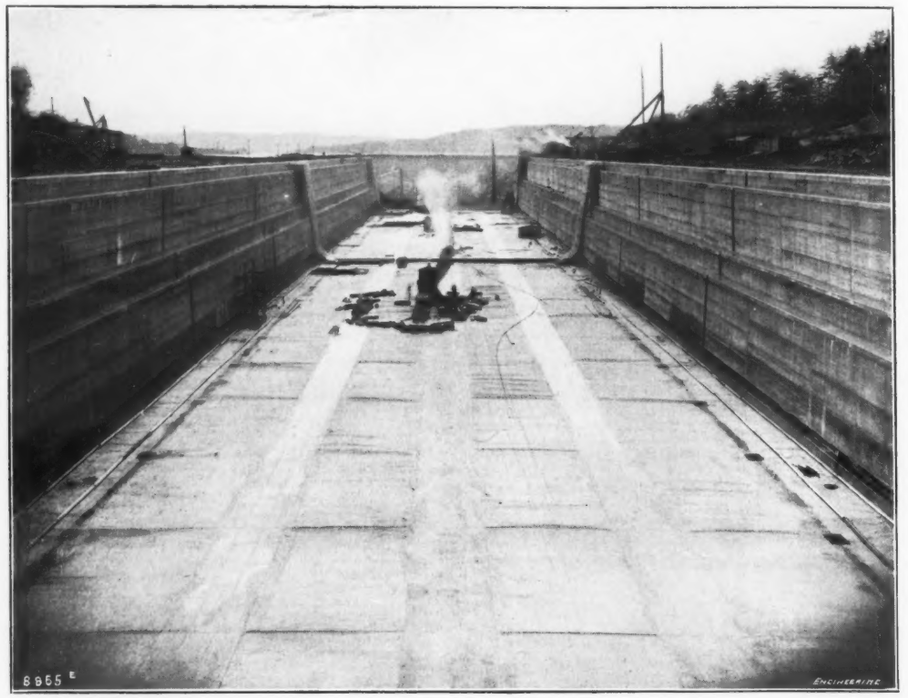


FIG. 4. VIEW OF DOCK LOOKING TOWARDS ENTRANCE.

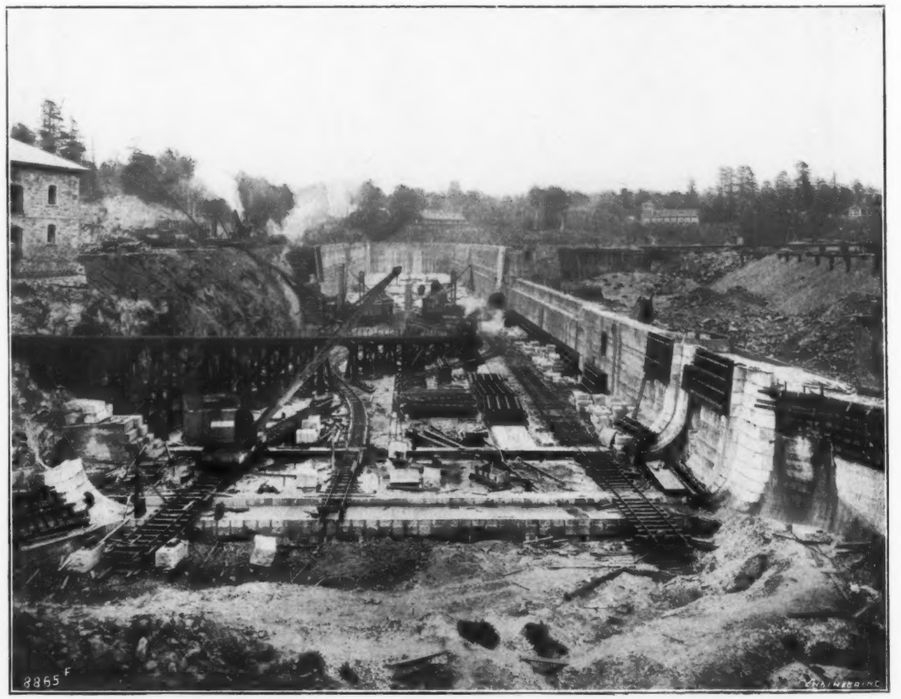


FIG. 5. VIEW OF ENTRANCE DURING CONSTRUCTION.

FIG. 6. VIEW OF WORK ON SUCTION-CHAMBER, SHAFTS AND CULVERT CONNECTION TO DOCK, MAY 31, 1924.

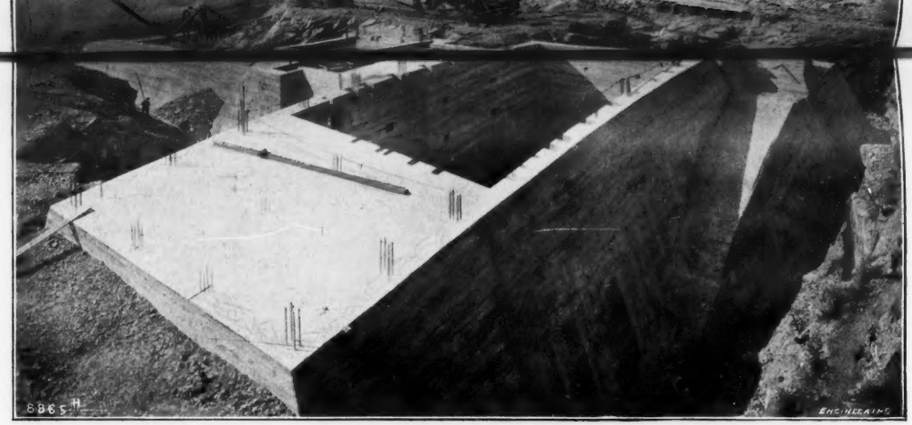

FIG. 7. MONOLITHIC SUBSTRUCTURE FOR PUMPING STATION AND CULVERT CONNECTION TO DOCK, SEPTEMBER 4, 1924.

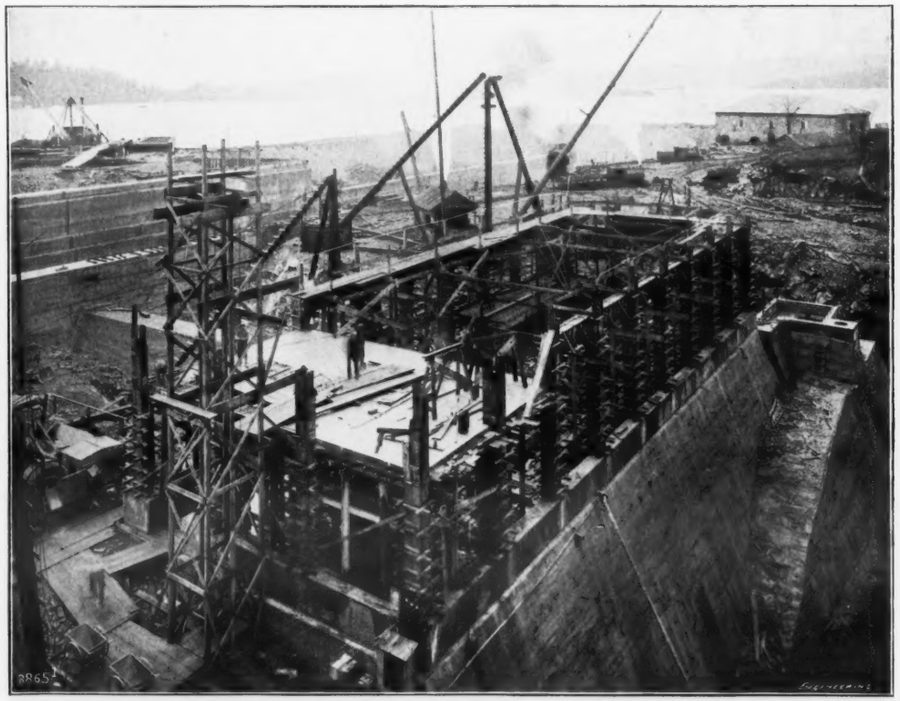

FIG. 8. SUPERSTRUCTURE OF PUMPING STATION IN COURSE OF ERECTION. VIEW FROM BACK, NOVEMBER 4, 1924.

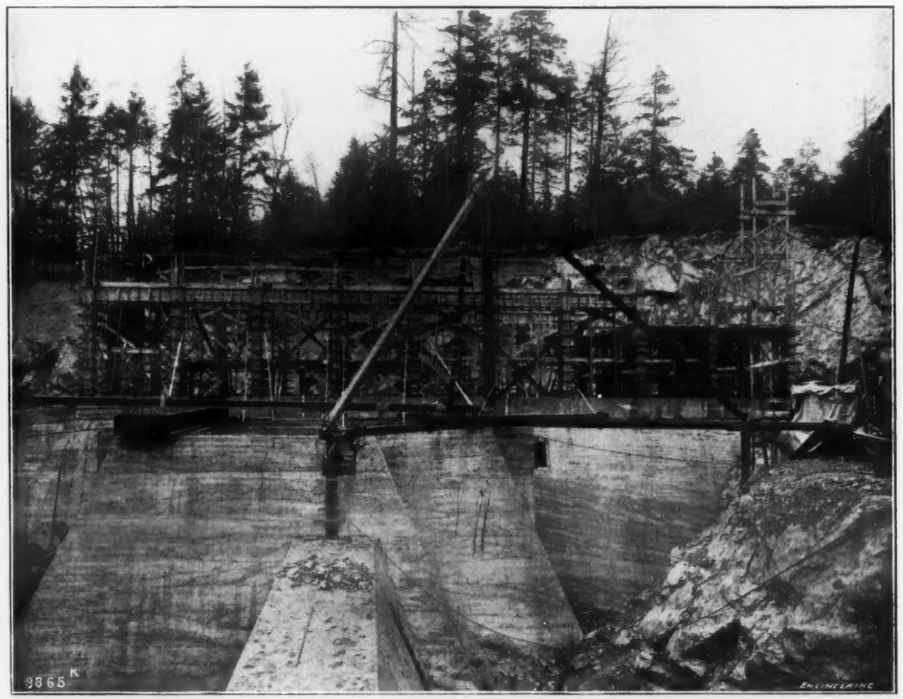

FIG. 9. PUMPING STATION, SHAFT AND CULVERT CONNECTION MONOLITH. VIEW FROM DOCK SIDE, NOVEMBER 4, 1924.

# ENGINEERING.

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*Two-Page Plate.—THE CANADIAN GOVERNMENT DRY DOCK AT ESQUIMALT, BRITISH COLUMBIA.*


# ENGINEERING.

*FRIDAY, JANUARY* 23, 1925.


## BOUNDARY LUBRICATION.

WHILST Osborne Reynolds succeeded in devising a mechanical explanation of the friction of fully lubricated surfaces, it has been argued by some that his hydrodynamic theory has no bearing on ordinary journal lubrication where the oil film is incomplete, and that to explain this it is necessary to introduce a new concept. This is known as "boundary lubrication," the idea being that with a good lubricant a layer of molecules "welds" itself to the opposing surfaces, making these surfaces those of solid lubricants, whatever this term may imply. Osborne Reynolds, on the other hand, maintained that the hydrodynamic theory applied equally to imperfectly lubricated, as to fully lubricated, bearings, and held that the differences in behaviour were due to the circumstance that with such bearings the load was concentrated on the "high points" of the opposing surfaces. Round these the lubricant must be collected by surface tension, and should any movement of the opposing surfaces occur, there must undoubtedly be hydrodynamic lubrication in these regions. It does not seem possible to avoid this conclusion, and as a first result we get accordingly the certainty that in the various experiments which have been brought forward to demonstrate "boundary lubrication" there must certainly have been some amount of "hydrodynamic" lubrication, and it is for the advocates of the new view to prove that the whole of the lubrication was not thus to be accounted for. It may further be added that Osborne Reynolds claimed that under the conditions of scanty lubrication the friction on his hydrodynamic theory would be proportional to the load and independent of the nominal area of contact, which is what experience shows to be the case. Unfortunately, however, Osborne Reynolds has given no indication of the line of thought which led him to this conclusion, and the statement remains therefore a mere *obiter dictum*, but, as such, that of a man who had a very exceptional insight into the mechanism of physical processes.

On Osborne Reynolds' theory the problem of the resistance of greasy surfaces is a problem in fluid friction, whilst on the opposing view, the matter is a question of solid friction. It becomes therefore of interest to examine the views as to the nature of solid friction, entertained by the principal protagonist of the newer theory. These will be found fully set forth in the "Fourth Report on Colloid Chemistry," issued in 1922 by the Department of Scientific and Industrial Research. In this volume the biologist, Mr. W. B. Hardy, F.R.S., who has made many very careful experiments on solid friction, explains the views at which he has arrived, and these seem to us to be in certain respects not a little remarkable.

Former students of solid friction were led to the conclusion that the friction of solids was due to the "asperities" of the opposing surfaces. Mr. Hardy argues that the experimental results prove that if this be true, the asperities must be of molecular dimensions, and he asserts that if the resistance to motion were due to the inter-engagement of such asperities, it would be impossible to explain the fact that the total friction is independent of the area of the opposing surfaces, and proportional to the load. This rule, he states, holds even in the case of the friction between a clean watch glass and a clean sheet of plate glass, although as he points out the nominal area of contact varies, in this case, as the $\frac{2}{3}$ power of the pressure applied. This independence of the friction and of the area of contact is, he claims, sufficient to show the error of the older view. It would seem, however, that this conclusion does not necessarily follow from the premises. When the load on the watchglass is increased, the alteration of the nominal area of contact is not the only phenomenon involved. The points previously in contact are not unaffected by the increase of pressure, and, further, it may be observed that in any case the true area of contact is very much less than the nominal, since it is impossible to make surfaces absolutely true to form so that they bear all over. In fact, the whole matter is exceedingly complicated, and until the problem presented has been fully analysed, the observation cited cannot suffice to overthrow the older view.

In the meantime it will be of interest to see what Mr. Hardy offers us in lieu thereof. He claims that solid friction arises from a certain cohesion between the molecules of the opposing surfaces. "To understand how two molecules may act, consider an interface between two masses of matter. A molecule on one side of the interface will be attracted by the matter on the other side, which is within the range of its force of attraction. A tangential force will therefore tend to move the molecule from its position of equilibrium." On the succeeding page to that from which this quotation is taken, he definitely speaks of the "cohesion" between the molecules of the opposing surfaces and compares the failure when slip occurs to the rupture of a more or less plastic solid.

A strong argument against the validity of the hypothesis thus put forward seems to lie in the fact that when slip ensues between clean, solid surfaces, scoring or other injury always occurs. Now it is hardly conceivable that the attraction of a molecule in the one surface to another in the opposing surface should be greater than its attraction to its immediate fellows below and around it. If the intimate character of the phenomenon were as Mr. Hardy describes it, slip ought, it would seem, to occur without any mechanical damage whatever, whilst if there be actual interlocking of the "asperities" this scoring is exactly what we should expect. On Mr. Hardy's theory the forces causing solid friction are tractions, the cohesion between the opposing molecules having to be overpowered. On the other view the forces concerned would be the thrusts and stresses involved, the same in character as those arising in the collision of the molecules of a gas and the "asperities" concerned would either have to yield, or the load be lifted in some way, before slip could occur.

Another of Mr. Hardy's statements in this paper

seems puzzling. He says that "at the free surface of a solid the condition of minimum of potential of the surface energy involves an orientation of the molecules of the surface layer such that their major attractions are in the plane of the surface." He brings this forward in explanation of the fact that when two very perfectly finished surfaces (such, for instance, as those of the Johanssen gauges) are brought into contact they adhere firmly together unless they have been previously very thoroughly cleaned, in which case there is no perceptible adhesion.

Beilby has shown, however, that the layers of a polished surface consist really of a super-cooled liquid, and according to Van der Waals the density of the surface layers of a liquid is less than the average of the mass, the molecules becoming further and further apart as the surface is approached, and consequently the attractive forces are less at the surface than further in. If, on the other hand, Mr. Hardy is not considering this surface as a super-cooled liquid, but as a normal elastic solid, then it is not the case that resultant tractions are a maximum where the potential energy is a minimum. In any case, however, the resultant force on any molecule must be greatest normal to the surface, and not tangential to the surface, as Mr. Hardy's language would appear to indicate.

It does not seem to us, therefore, that these views of the nature of solid friction afford any very sure basis for the hypothesis of "boundary lubrication," according to which a layer of oil one molecule thick can serve as an effective lubricant. It is now admitted that a good lubricant welds itself to the surfaces it lubricates, and were it possible to coat two surfaces each with a layer of oil one molecule thick, we would naturally expect that the force under which slip occurred would not be the same as with two clean surfaces. It would be an abuse of language, however, to call this lubrication. We have only to replace the layers of oil by, say, an electrolytically deposited layer of gold, also of one molecule thick, and we should again expect that the force under which slip occurred would be changed by the deposit. If the result were a decrease, no one would think of saying that the gold acted as a lubricant, and from the physical standpoint the two cases are evidently identical.

As a matter of fact, however, in a letter "On the latent period of lubrication" (*Nature*, February 10, 1923) Mr. Hardy and Miss Doubleday describe observations which to our mind afford pretty conclusive proof that in their experiments they were not dealing with unimolecular layers of lubricant, and that the actual lubrication observed was hydrodynamic. They say, "Most lubricated surfaces have the curious property that the friction falls after the lubricant has been applied until a steady state is reached after an interval which may vary from a few minutes to a few hours.

"The most striking fact is the influence of the slider. The final steady state is never reached unless the slider is in position. Surfaces which have been freely exposed to vapour or to an excess of fluid resting on them have always a high friction when first put into contact. The lowest friction is only given by a film of lubricant which has been enclosed for some time between two solid surfaces." To explain these observations the authors observe that the molecules of a good lubricant are like rods loaded at one end, and that they tend to orient themselves normally to the surface. This view is now very thoroughly established, but it is difficult to accept the view that the time lag observed in the authors' experiments represented the time required to effect this orientation. When a film of oil spreads over water, the orientation seems to be practically instantaneous. Moreover, the oil molecules at lubricated surfaces are being jolted up and down millions of times per second owing to the thermal agitation, and it is very difficult to believe that any orientation which cannot be completed within the myriads of oscillations corresponding to an interval of a few seconds would be effected by a longer lapse of time. Again, the fact that the phenomenon is only fully developed with the slider in place seems highly significant. In view of the "polar" characteristics of the molecules of the lubricant, it would be natural to expect that the approximation of the two surfaces would tend to disturb any existing orientation rather than to promote it, as will easily appear if we regard the oil molecules as small magnets each tending to fix, say, its north pole on the surface to which it adheres. These considerations indicate that an explanation of the observations must be sought elsewhere, and if we assume that Mr. Hardy was not really dealing with mono-molecular films, another explanation of the time lag becomes possible.

When oil spreads on water it tends to form a layer one molecule thick. Any excess over that required to cover thus the whole water surface collects itself into little lenses, the aim of the oil being to get as large an area as possible of mono-molecular thickness. Hence the lenses in question may be, and commonly are, very many molecules thick.

It is reasonable to assume that the same phenomenon will occur when oil spreads over a metal surface. The surplus fluid will again gather itself into these little lenses, and when two very scantily-oiled surfaces are pressed together these lenses will tend to collect round the regions of closest contact. For this, time is required, but once these aggregations are achieved the conditions for hydrodynamic lubrication are satisfied. On this view, therefore, the question of lubrication does not enter into the study of static friction. The adsorbed oil acts then merely in the same way as would an electrolytically deposited layer of some metal having a lower "clean" static friction than that of the surface on which it is deposited. In kinetic friction the lubrication is hydrodynamic, and the difference between a good and bad lubricant lies in the fact that the bond between the metal is stronger in the first case than in the last. Under the conditions of imperfect lubrication the shearing stress tending to tear the oil away from the surface becomes very great, and with a bad lubricant the adhesion breaks down and the two solid surfaces come into contact.

In his article on "Lubrication" in the tenth edition of the "Encyclopædia Britannica" Osborne Reynolds, suggested rather than asserted, that lubrication failed when the motion of the fluid became turbulent. This view, however, seems to involve difficulties in face of the fact that the critical speed at which turbulence occurs varies inversely as the characteristic dimension of the "waterway." Any inset of turbulence would necessarily cause the surfaces to come into closer contact, and thus automatically tend to stamp itself out.

The experiments described by Dr. Stanton in his Thomas Hawksley lecture last year afford the means of calculating a lower limit for the strength of the bond uniting certain lubricants to steel. Mathematically speaking, the conditions in which these experiments were made lead to the same equations as those developed in ENGINEERING, August 11, 1916, for the resistance of one lubricated surface rolling over another, but the ratio of the maximum shearing stress to the maximum pressure developed in the film is twice as great as in the case of the "rolling" friction. It thus appears that in the Teddington experiments we have

$$\frac{\text{maximum shear stress}}{\text{maximum oil pressure}} = 1.259\sqrt{\frac{h_0}{R}}$$

where $h_0$ denotes the least thickness of the oil film and R the reciprocal of the relative curvature of the two opposing surfaces. In one of Dr. Stanton's experiments with castor oil as a lubricant, failure occurred when the maximum oil pressure was $3\frac{1}{2}$ tons per sq. in. The corresponding value of $h_0$ was 0·000,046″ whilst R was about 8·85″. If we calculate the value of the maximum shearing stress from the above expression, we get 22·5 lb. per sq. in. as the shear stress at which failure occurred and the bond between oil and metal gave way. This figure is surprisingly low; but it has to be borne in mind that it is a lower limit, since the true maximum pressure was not observed in the Teddington experiments but only the space and time average of this pressure. Any inequalities of form in either bush or bearing would imply higher local pressures. The two surfaces were undoubtedly very good, but when $h_0$ is of the order of $\frac{1}{40,000}$″ small inequalities become relatively large.

## WATER POWER RESOURCES OF GREAT BRITAIN.

SOME of the disabilities attaching to water power development were clearly brought out in the interesting lecture delivered to the Greenock Philosophical Society on Friday evening last, by Mr. Gilbert Thomson, who was the James Watt lecturer for the current year. From a narrowly national standpoint, it is perhaps to be regretted that the drawbacks are not even greater; since liberal as Nature has been to us in many respects, the possibility of any very large development of water power cannot be included in the list of her benefits. The Water Power Resources Committee estimated that taking Great Britain as a whole, only about 375,000-h.p. shows promise of being commercially available to-day. This figure, it is true, relates only to schemes of some magnitude, and ignores the innumerable cases in which small streams might be utilised to develop correspondingly insignificant amounts of power. In America, Canada and in some European countries, the figure of available water horse-power runs into millions. The comparison is not a cheering one, and is the less so in view of our enormous national liabilities. At the end of the Napoleonic wars, our debt amounted to about 40*l.* per head of population. To-day, even taking the most sanguine view as to refunds and reparations, it amounts to at least 150*l.* per head. Thus, baldly stated, the burden appears, however, rather heavier than it is in reality. There has been of course, an enormous depreciation of monetary values during the century. The one stable standard of value, which changes little with time, is a day's work by unskilled labour. The muscular output of a well-nourished labourer cannot, in fact, differ greatly from generation to generation. Reckoned on the basis of the cost of a day's unskilled labour, it would appear, therefore, that our burden of to-day is of much the same relative intensity as it was at the conclusion of the Napoleonic wars. At that time, however, we had vast undeveloped resources. Fuel and power were cheaper here than anywhere else, and, moreover, we profited largely by the export of coal and other wasting assets. These conditions no longer exist. Our fuel costs are now high, and our poverty in the matter of possible water-power developments promises little relief in this direction. It is accordingly not wholly displeasing to realise that though running costs are low with water, capital costs are frequently very high. In fact, a few years back, Carville was supplying current for electrolytic processes more cheaply than the Niagara Power Company.

As Mr. Thomson pointed out, an average figure for the coal consumption in existing steam-operated power stations is about 3 lb. per kilowatt-hour. To obtain the same amount of power from 3 tons of water a fall of about 500 ft. would be required, and such falls are not common. With a 10-ft. fall the quantity of water to be passed would be 150 tons; and the plant and machinery would be correspondingly bulky and costly. Hence, though water costs nothing, the cost of using it for power production may be very large. Mr. Thomson recalled in this connection the story of the indignant housewife who declared it was an outrage that a rate should be charged for water, which a kind providence supplied free, ignoring the fact that the beneficence of providence had not extended to "putting in the pipes." This unreflective attitude of mind, it should be added, is by no means confined to the uneducated. Ruskin, with his characteristic incapacity to think things out, made the same blunder when he asserted that our power requirements should be met by windmills, as the wind would cost nothing. Unlike Socrates, he did not realise how little he knew, or before committing himself he would have submitted the point to some engineer. To some minds, however, what sounds plausible is what is true, and Ruskin quite failed to appreciate the extreme importance of establishment costs, which are, in fact, the ruling factor whenever it becomes a question of utilising some natural source of power.

Another difficulty which arises with water power lies in the fact that few industries require

a 24-hour supply. One ingenious method of overcoming this drawback was described by Mr. Thomson, who stated that at Walkerburn on the Tweed there is a 10-ft. fall, from which some 220 h.p. can be continuously supplied. The mills taking the power, work, however, for only 50 hours per week, but require during this period about 450 h.p. The balance is made up by using the turbines at the fall to pump up water, during idle hours, to a tank situated 1,000 ft. higher up the river bank. With this high head the amount of storage required is not excessive, and a moderate diameter can be used for the connecting pipe. From this tank water is drawn during working hours to drive a Pelton wheel, which generates the additional 230 h.p. required.

In other cases trouble arises from the great fluctuation in the amount of water available at the power station. Thus when a proposal was made some years since to develop power at the Falls of Clyde, it was dropped because detailed investigation showed that the cost of storage would be prohibitive. The scheme has, however, now been revived, with a steam plant, in conjunction with the hydro plant to take all the load in excess of the capacity of the falls at any particular moment. Swiss rivers, Mr. Thomson pointed out, being very largely glacier-fed, are less variable than the Scotch, and this has facilitated water-power developments there, but, even in spite of this, steam stand-by plants have been provided at quite a number of Swiss hydro-electric stations. At Niagara, of course, the conditions are ideal, as the great lakes form a reservoir of such capacity as to ensure a practically constant supply at the power station.

In view of water resources being so limited, it is a matter of importance that water power should be used to the best advantage. It would appear undesirable, for instance, to use current thus derived for domestic heating purposes, since an electric current represents energy of a very high grade, whilst low-grade energy is all that is needed for low-temperature heating. The most advantageous use of the current will presumably be for electro-metallurgy and high-temperature furnace work. Even here, however, the advantage varies greatly with the nature of the ultimate product. Thus the Water Power Resources Committee took the cost of one kilowatt-year as 14*l.* in Sheffield and as 4*l.* in the Highlands. In the latter, however, there is no demand for possible products, which if produced, must be sent elsewhere for disposal, so that heavy freight charges would have to be included in the total costs.

It is not, therefore, all electric smelting or electrolytic operations, which could be profitably conducted in the Highlands. To melt electrically one ton of scrap steel requires but one-fifteenth of a kilowatt-year, whilst to produce a ton of a high grade ferro-alloy needs two kilowatt-years. In the former case the saving effected in conducting the work at a hydro-electric power station rather than at Sheffield would be more than offset by the freight charges involved. The ferro-alloy, on the other hand, could be most cheaply produced by water power. To produce a ton of aluminium requires, Mr. Thomson stated, energy to the amount of about 3½ kilowatt-years, whilst a ton of calcium carbide needs 2¾ kilowatt-years. Both operations, therefore, can, even in spite of freight charges, be more profitably carried out with water power than with steam power.

About four-fifths of the total water-power resources of Great Britain are concentrated in the Highlands, and we may expect considerable industrial developments there in the future. The Highland Glens may thus be repopulated with a new type, as such electrical undertakings require but relatively little unskilled labour. The conversion of these solitudes into industrial centres need not, we would add, necessarily adversely affect the amenities of the district. The history of the Manchester scheme for drawing a water supply from Lake Thirlmere is of interest in this connection. When first broached, the project was denounced wholesale in the daily press, as certain to ruin the beauty of the district. The actual result, however, has been an enhancement of this.

## BRITISH TRADE WITH ARGENTINA.

THE material prosperity of the Argentine, a purely agricultural and pastoral Republic, is almost entirely dependent on favourable climatic conditions. In other words, the purchasing power of the country in the matter of manufactured goods of all kinds is, to a great extent, regulated by the quantity and value of the produce it is able to export. In a Report on the Financial, Commercial, and Economic Conditions of the Argentine Republic, prepared by Mr. H. O. Chalkley, C.B.E., and issued by the Department of Overseas Trade (H.M. Stationery Office, price 2*s.* net), it is stated that a successful harvest is anticipated this season; this, coupled with the fact that the exchange is improving and that world conditions generally are more settled, has given rise to much optimism.

British trade with the Argentine rests on solid and secure foundations. The competition of Continental countries with lower costs of production and depreciated currencies, is the greatest obstacle under present circumstances. In established connections, reputation, methods, agents, credit terms and banking and shipping facilities, British manufacturers are in most cases as well situated and in some better than those of competitive countries. But competition having reached the pitch it has British manufacturers and merchants cannot afford to stand still and must keep up with the changing developments.

Importations of coal in 1923 were 2,579,466 metric tons compared with 4,046,278 tons in 1913. During the first eight months of 1924 imports of British coal totalled 1,972,342 tons, showing an increase of 388,619 tons over the corresponding period of 1923. American coals totalled 162,388 tons during the 1924 and 107,358 tons during the 1923 period. A cargo of German coal arrived recently, and it is thought that in the near future German coal may compete with British on the River Plate.

In constructional iron and steel goods, Belgium holds the Argentine market for the present on lowest prices. There would seem, however, to be ample stocks on hand to enable buyers to await the course of prices. Trade in corrugated galvanised iron sheets has been for many years in the hands of British manufacturers. Out of a total of 56,160 tons imported during the first nine months of 1924 the United Kingdom supplied 54,650 tons. In spite of the competition of United States manufacturers the trade in Welsh tinplates is fully maintained, this being due to the well-established superiority of the Welsh material. Although the British product would in many cases be preferred, wire of all kinds is at present supplied by Germany, the United States, and Belgium on account of lower price. In the matter of tubes and fittings for gas, water and steam, British firms have found it very difficult to compete with German and Canadian manufacturers, who have done the biggest trade. Large orders for cast-iron water mains and connections have been placed in Germany and France. Whereas 81,222 tons of cast tubes, pipes and fittings were exported to the Argentine from this country in 1913, the figure for 1923 was only 8,773 tons.

The Argentine agricultural machinery trade is a problem which should be studied closely by British manufacturers, who cannot quietly acquiesce permanently in the monopoly of this valuable trade by the United States, which increased its exports to the Argentine from 5,360,845 dols. in 1922, to 12,975,828 dols. in 1923, while in 1923 the United Kingdom's exports to the whole of South America amounted only to 110,538*l.* This circumstance is entirely owing to the war. The success of United States manufacturers is due to the fact that they have introduced new types of machines which are cheaper and suit Argentine conditions better than those previously in use. This particularly refers to the harvester-threshers now generally employed in place of large threshing sets. The report, however, goes on to say that prices of American machines are now such that there is every reason to believe that the majority of machines and implements required by Argentina could be manufactured in the United Kingdom at a competitive price, and the reputation of British goods is still high enough to secure a preference at the same price. The Argentine market is large enough to be separately catered for, and the problem presented is a serious technical study in the country of the types required, without reference to the fact that the latter may have little application in the home market.

The trade in electrical machinery appears to be almost entirely in German hands; this is due, partly to German ownership of most of the electrical supply companies, and partly to the fact that German makers have been able to underbid others in the market.

During 1923 and 1924 the importation of motor-cars, almost exclusively from the United States, has been on a large scale and shows no signs of slackening. With regard to motor tyres, United States manufacturers have 41 per cent. of the trade, Canadian 14½ per cent., French 14 per cent., British 11 per cent., German 9 per cent., and Italian 8 per cent.

Turning to questions of production and industry within the Argentine, it is interesting to note that cotton growing, although of comparatively recent introduction, is expanding rapidly. With regard to petroleum, the total Argentine production of oil is estimated to supply only between 12 per cent. and 15 per cent. of the country's total annual fuel requirements. As large quantities of petroleum products are imported annually the Government is anxious to increase the output of the home wells, but the policy likely to be adopted is uncertain, with the result that the increase in capital invested was small in 1923. In spite of the known existence of minerals containing iron, copper, lead, silver and other metals, no attempt has so far been made to exploit these natural resources, and the mining industry may be said not to exist at all in the Argentine.

The factories producing manufactured goods are situated in or near Buenos Aires; the articles turned out are chiefly for domestic or household use. These are protected by high tariffs which seem to be gradually shutting out British goods in certain lines.

As is the case in all agricultural countries, the question of transport is of vital importance. Much of the prosperity of the Argentine is due to the continuous investment of British capital, and eight of the thirteen railway systems are in British hands. The latter, unfortunately, have had to record losses during the past year owing to exchange fluctuations; these, however, have been in a great measure covered by increased receipts and, taken as a whole, the year has proved a distinctly favourable one. In order to keep pace with the constantly increasing requirements of the country, extensions and improvements are being vigorously pushed forward, thus creating not only a big demand for labour, but necessitating large orders for rolling stock, rails, constructional steel and railway material of all descriptions.

Port extension works are proceeding somewhat slowly, but it is anticipated that the government will shortly invite tenders for dock equipment on an extensive scale, comprising grain elevators, loading and discharging equipment, electric plant, cranes and the like. An account of the new docks under construction at Buenos Aires was given in ENGINEERING, vol. cxiv, p. 97. Some of these works are practically completed, but are not in service owing to lack of equipment for which the necessary funds had not been available.

Few countries have escaped the unsettling influence of the Great War, and the Argentine Republic is no exception to the rule. Although food shows an increase of only 2 per cent. over 1914 prices, the cost of living in other directions has greatly increased. On the other hand, unemployment is practically non-existent and capital is free from income tax. Spasmodic strikes amongst various grades of workmen have been somewhat frequent of late, but all have been of short duration, and were settled directly by the parties concerned without outside intervention.

In spite of financial, legislative and political handicaps, the outlook in Argentina is promising, and should be reflected in greater activity in the import trade for 1925, with an increased demand for

goods which the United Kingdom can supply, a demand which is persistent in spite of high tariffs and keen foreign competition.

## NOTES.

### DIFFICULTIES IN WELDING.

SOME of the peculiar difficulties associated with welding processes were dealt with in a lecture by Mr. C. R. Darling at a meeting of the British Acetylene and Welding Association held in the Old Colony Club, London, on Thursday, January 15. The lecture was given the title "Scientific Aspects of Welding" and in it references were made to the great disadvantage found in welding that it was impossible to control the temperature with anything approximating to precision. As an alternative to oxy-hydrogen and oxy-acetylene flames for welding an oxygen and fuel-oil flame was suggested as a means of securing a more suitable temperature. The action of fluxes in welding was not easy to follow and was worthy of the closest observation and experiment. In part it was chemical, as it facilitated the reduction of the oxides to pure metal, and in part physical, as the metal passed through the layer of oxide or flux. In America no fluxes were used in general work in electric arc welding, but in this country all kinds of coatings were utilised. The value of the flux coating seemed to lie in the ease with which the arc, from electrodes so provided, could be maintained. The use of a flux made good work a possibility, even when the welder had little skill. In referring to spot welding the lecturer called attention to the welding of nickel to molybdenum, the two having a difference in melting temperatures of about 1,000 deg. C., in the manufacture of wireless valves. When dealing with cast-iron fractures it was common practice to use alloys containing copper for the welding rods, in order that a weld might be obtained which was machinable at its junction to the parent metal. The lecturer concluded with some experiments, in which the forces due to surface tension were demonstrated, and it was suggested by Mr. Darling that surface tension actions might play an important part in the deposit of welding metal.

### THE FUSION RETORT FOR LOW-TEMPERATURE CARBONISATION.

The conditions for "Low-Temperature Treatment of Bituminous Materials," which Mr. T. W. Stainer Hutchins outlined on the 16th inst. before the Chemical Engineering Group of the Society of Chemical Industry, demand a good deal of consideration. The temperature should not, he said, at any point in a cross section of the retort vary by more than a few degrees between the minimum and maximum; oil vapours liberated should be prevented from passing through the material; the retort should permit of adding water or steam to bring the total moisture up to 5 per cent.; coal or other material richer than this in moisture should first be dried; gases used for internal heating should previously be diluted to avoid excessive temperatures, and the general treatment should be applicable to both fines and large. To meet the conditions of uniform heating without the use of lead baths and of superheated steam, which Mr. Hutchins considered uneconomical, he was, he said, using rotary tubular retorts provided with baffle agitators, as introduced by himself at Middlewich for drying the calcium carbonate resulting from the liberation of caustic soda from soda by the aid of caustic lime. These agitators were skeleton drums provided with four or more longitudinal fins cut out so as to form staggered blades. The fusion retort of Mr. Hutchins, 50 ft. long, 4 ft. diameter, made of $\frac{1}{2}$-in. steel, would have two pairs of rollers revolving from $3\frac{1}{2}$ to $6\frac{1}{2}$ times per minute. There were special valves for feeding and discharge, the latter being a plug valve of boot shape and fitted with an oscillating spindle carrying a push plate. The agitators or breakers should have about two-thirds the cross section of the tube. Such baffle agitators, fixed to a longitudinal shaft or riding on it, were not, of course, new. But Mr. Hutchins divides his agitator into several (five or more) independent sections, which are placed loosely in the retort so as to keep falling over and to give an excavating and stirring movement to the material. As the heavy breakers would always tumble on a cushion of material, the tube would not suffer. Mr. Hutchins preferred to mount his retort horizontally, without inclination, and provided an overflow weir near the discharge hopper into which the discharge valve mentioned is fitted. The retort is surrounded by the longitudinal heating chambers with, outside them, some combustion chambers, the two-chamber system communicating by adjustable ports. The heat flow outside, and, if desirable, inside, is in opposite direction to the flow of the material. Doubts were expressed at the meeting as to the advantages of the novel features. Mr. Hutchins gave particulars of tests conducted with various coals, peat, sawdust and oil shales.

### THE ORGANISATION OF THE GERMAN NAVY.

The Defence Ministry of the German Republic has recently issued an official statement concerning the organisation of the post-war navy. It is a somewhat remarkable pamphlet, which though published under the authority of a democratic defence minister, opens with an introductory diatribe on the iniquity of the Treaty of Versailles, and the political slavery to which it has reduced the German people. The Republican Government has undoubtedly simplified the organisation of the high naval command. The head of the navy is now the Marineleitung, of which a vice-admiral is in charge, who is responsible for all matters relating to executive command and administration. The Marineleitung is divided into three departments which we should call "operations," "construction" and "supplies." This is an enormous advance upon the complications of the imperial *régime*, when the Admiralty and its naval secretary were independent of the operations division and the chief of the naval staff; whilst the chief of the "imperial naval cabinet," nominally the Emperor's adviser on appointments and honours, was in his turn independent of either. The squadrons afloat have been placed under a single commander—the Oberbefehlshaber der Seestreitkrafte. He now flies his flag in the battleship, the Braunschweig, and has the battleship division, consisting of the Braunschweig, Hannover, Elsass and Hessen—all of them 13,000-ton battleships of the pre-Dreadnought type—under his immediate orders. The other two battleships allowed to Germany under the Versailles Treaty are not in commission. Under the Oberbefehlshaber are the commanders of the Baltic and North Sea Squadrons; each of these is composed of three light cruisers and a destroyer flotilla. This completes the organisation afloat. On land there are commanders of the Baltic and North Sea stations who are responsible for all the shore establishments, torpedo and mining craft, and wireless and reporting stations within their commands. In the new organisation of the Germany Navy all the coastal fortresses are put under naval command. The "Kommandantur" at Borkum includes the forts of Borkum, Norderney and Juist; that at Wilhelmshaven, those of Wilhelmshaven, Schillig and Langeoog; that at Cuxhaven, Neuwerk, St. Peter, Brunsbüttel, Sylt and Amrum. The coast defence of the Baltic is divided between the Kommandanturs of Pillau and Swinemunde. The garrisons of these defences are divided into six coast defence divisions. Numbers 1, 3 and 5 are allotted to the Baltic, and the remainder to the North Sea. The two Kommandanturs are placed under the commanders of the Baltic and North Sea stations. The system of coast defence much resembles that which the French Navy has adopted; and though it differs absolutely from our own, seems to be the one most suited to a navy which is only strong enough to deal with an attacking force if it is assisted by the shore defences.

### CONDENSER-TUBE CORROSION.

The estimated annual world loss of metals due to corrosion runs into millions of tons; this fact, coupled with the certainty that the mineral resources of the earth are not inexhaustible, has led metallurgists to devote much time and labour to the study of these deleterious effects upon industrial alloys. That corrosion is in a great measure preventable is the general conclusion arrived at and this acts as an incentive to further research. Exposure to sea water undoubtedly gives rise to most severe forms of corrosion, and materials which withstand land conditions satisfactorily often fail rapidly when used for marine purposes. In marine work waste of metal is not the only factor to be taken into account; delays brought about by repairs and replacements, to say nothing of expenses incurred, are usually serious. The corrosion of the tubes of surface condensers, on the water side, has for years proved a matter of great concern to marine engineers and a paper upon this subject read before the Liverpool Engineering Society by Mr. J. Austin, on the 21st inst., brings out some points which appear to deserve attention in shipbuilding circles. The author states that the reduction in cooling surface in square feet per horse-power in modern condensers from about 1·75 to about 0·8, has only been possible by the adoption of increased speed of flow of the circulating water, with the inevitable corollary that the scrubbing effect causes much more rapid corrosion than was formerly the case. Mr. Austin dealt with experiments first made with various alloys with a view to finding a material for condenser tubes which would withstand modern conditions but the results were not very conclusive. A second investigation of which he gives an account seems to have been more productive. This consisted in coating the inside of the tubes with a bitumastic solution. After much experimental work it was found that an ordinary paint-sprayer fitted with an extension nozzle and worked by means of compressed air, gave the best results, it being of importance that the coating should be thin and even. The process is now used by the Cunard Steamship Company; the condenser tubes are first thoroughly cleaned and dried by allowing a slight leak of steam to enter on the steam side. A first coat of the solution is then sprayed on by means of the air-spray gun to which allusion has already been made. The tubes are then allowed to dry, this being expedited by the use of fans, and a second coat is sprayed on. The resultant protective layer is smooth, glossy, and even and has proved highly successful in service. Out of ten condensers coated, representing a total of 28,500 tubes, only 21 of the latter have failed, over a period ranging from 3 to 15 months. The fact that, upon subsequent examination, these failures were found to have been already badly corroded before coating, further enhances the value of the results. Failures in tubes of the same condensers, before coating was introduced, amounted to 441, ranging over a period of from 3 to 10 months. The great advantage of the process is that the condenser tubes are treated in position on shipboard. Moreover, the apparatus is portable and comparatively easy to manipulate. No mention is made, by the author, of the effect of the sprayed coating on the conductivity of the tubes. It is possible that the thinness of the coating causes loss in conductivity to be negligible, but it would be as well for engineers to be definitely reassured on this point. The fact that tubes might be treated before being built into the condenser is a matter which is touched upon in the paper. This should present no serious difficulty.

## INVESTIGATION OF THIN FILMS BY MEANS OF X-RAYS.

IN opening the season of evening discourses at the Royal Institution last Friday by a lecture on "The Investigation of the Properties of Thin Films by Means of X-Rays," Sir W. H. Bragg remarked that he would use the term "thin films" in a wide sense, so as to comprise the phenomena of surface tension, of light interference, soap bubbles, lubrication and catalysis. The effects in question were of universal occurrence and importance. Bodies generally acted on one another at their surfaces; the surface often differed from the interior, because it was a surface or because it was overlaid by some foreign substances; it had its own laws and required special examination. For this purpose X-rays were serviceable, and what had been learnt by their aid as to crystal structure proved useful in interpreting what was observed when the rays were passed through films.

Sir William next showed a number of phenomena

which were dependent upon the surface characteristics of a body. Thus grapes, immersed in soda water, floated, because bubbles of $CO_2$ adhered to the surface. Corresponding glass spheres, on the other hand, sank unless their surfaces were previously greased, since the $CO_2$ did not collect on the clean glass. Vapours of acetic acid, again, were converted into acetone if the electric furnace through which they passed contained thoria, to serve as a catalyst, but not otherwise. The lecturer also showed a number of experiments on the colours of thin films. These films had been obtained by cementing mica to glass with melted selenium. On subsequently stripping the mica off, thin flakes of varying thickness were left behind and gave interference colours ranging from black up to grey. A film, 2,100 Angström units in thickness, gave an easily-recognised violet tint, and between this and the thinnest, which showed

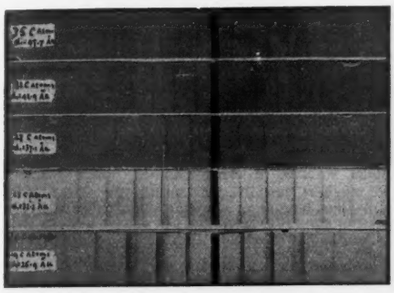


FIG. 1. HYDROCARBONS.

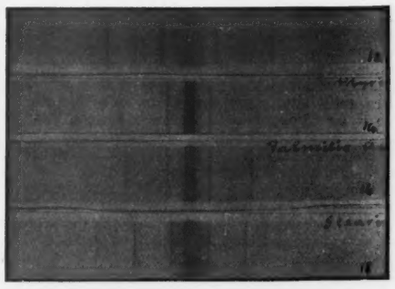


FIG. 2. FATTY ACIDS.

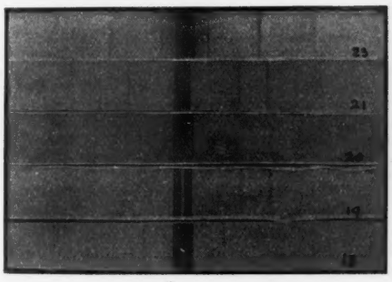


FIG. 3. KETONES.

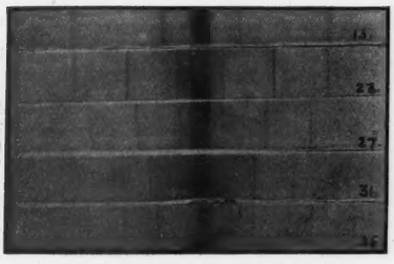


FIG. 4. DI-NORMAL KETONES.

black, R. Marcelin had distinguished no less than 300 distinct steps in the thickness of the flakes. In the case of soap bubbles, the black spots on their first appearance were small, but afterwards collected.

X-ray studies conducted in the Davy-Faraday Laboratory and elsewhere, by the lecturer with Drs. A. Müller, G. Shearer and others, proved, Sir William continued, that there was stratification in all these films. The first examination of organic compounds* had been made with flakes of solid paraffins adhering to glass plates on which they were melted. The molecules of these paraffin hydrocarbons consisted of chains of many $CH_2$ groups, with a $CH_3$ methyl group at each end. In the simple ketones an end group was replaced by a CO. $CH_3$ or other alkyl group, in the fatty acids by a carboxyl group CO. OH, these latter groups being relatively heavy. The molecules might lie in any direction; but there was generally some regularity. If the molecules were arranged in parallel lines, the ends, light or heavy, might point the same way → → or in opposite ways, → ←; in the next layer the arrangement might be the same or reversed, as boots were packed in a box. There were various reasons which led to the conclusion that when the fatty acids were spread over water, the heavy ends of the molecules, having a chemical affinity for the water, were anchored in the surface film, while the light, chemically inactive, chains stood vertically upward, like the pile of a carpet. That was in agreement with the X-ray analyses, which promised to clear up many obscure stereo-chemical problems concerning space configurations.

The lines of the X-ray spectra illustrated in Figs. 1 to 4, Professor Bragg proceeded, represented reflections from the planes in which the atoms (the scattering centres) were relatively concentrated. The measurements gave the spacings between those planes, which sometimes coincided with cleavage planes. There might be one or more molecules in each layer. In the case of the hydrocarbons, Fig. 1 indicated that as the number of carbon atoms (or of $CH_2$ groups) increased, the spectrum lines of different orders drew nearer one another, which meant that the spacings increased. To elucidate that point, Sir William threw ordinary grating spectra on the screen. With 200 rulings to the inch the diffraction bands were close to one another; as the number of rulings increased to 400 and 3,000 to the inch, the distances between spectral lines became greater. If we had two lines ruled on glass and scratched a third line between the two, the number of lines was doubled for the whloe grating, the spectrum widened out, and the even-order spectra were strengthened. Now, in Fig. 1 it was clear that the lines closed up as we passed from molecules with 19 carbon atoms to molecules with 23, 27, 31, 35 C, the spacings (for differences of 4 C) increasing from 26·7 to 47·9 A.U., or, on an average, by 1·5 A.U. for each C. The diameter of the carbon atom was itself about 1·5 A.U. The interpretation was that the molecules were arranged vertically between the planes, and that the different $CH_2$ groups were arranged, not exactly in straight lines (the distances were too small for that), but either in a zig-zag or in spirals, so that the fifth C atom was exactly above the first and fourth. The length of the chains increased with the number of $CH_2$ groups. These remarks applied to the strong lines of Fig. 1; the fainter lines enabled the investigator to draw conclusions as to the width (or thickness) of the chains.

The same general rule held for the fatty acids of Fig. 2—capric, lauric, myristic, palmitic and stearic acids, with 10, 12, 14, 16, 18 $CH_2$ groups, respectively. The odd-order spectra (first, third, &c.) were much stronger than the even orders (second, fourth, &c.). That suggested (as mentioned above) that these layers consisted of two molecules facing opposite ways →←, and that the number of scattering centres was distributed uniformly along the chain length, except at the ends. At the carboxyl end there seemed to be an excess of scattering centres, and at the methyl end a deficiency. If there had been an excess of scattering centres at both ends the even orders would be the stronger, as was the case with rock salt. That argument was further supported by the spectra of ketones (Fig. 3) and of di-normal ketones (Fig. 4). The latter were of the type $C_n H_{2n+1} - CO - C_n H_{2n+1}$; another configuration had been considered possible by chemists for these bodies. In the ketones the spacings seemed to be of the length of one molecule devoid of any active group. In the di-normal ketones the arrangement seemed to be as in the fatty acids, layers of two molecules with active groups facing →←; the odd-order spectra were strong, the even orders (equally pronounced in the ketones, Fig. 3) were faint. In the ketones the arrangement was →→, and the junction was equivalent to another line.

Professor Bragg further explained these features with the aid of the wooden models and glass table, mentioned in our abstract of his lectures on the "Crystalline Structure of Organic Compounds" (ENGINEERING, February 22, 1924, page 244, and subsequent issues). In the case of soap bubbles, the X-ray method failed to give results because their main constituent, oleic acid, was liquid; but "liquid crystals" had long since been studied by Lehmann and the analogies were of some assistance. The thinnest film in such bubbles appeared black because it reflected hardly any light. If we imagined a soap bubble as big as the earth, the thickness of the black film would be about the length of a fountain pen. In the film, the molecules stood side by side in a double layer; they held together much more strongly sideways than endways. The contracting tension in the black film was of the order of 1 or 2 tons per square inch; the film surface was very slippery, and other films were seen easily to slide on it. On each side, or skin, of the film, the molecules of oleic acid were standing erect; the one end of the mole cule had special attraction for the water and was rooted in it, the other end was free to the air outside. The black spot started when the two opposite skins came into contact inside; the water between them then ran out, or was squeezed out, and the two faces united. The molecules on the one side tied together those on the other, possibly, being staggered with regard to the central plane, and succeeded in acquiring the strength of a crystal.

Many molecules, the lecturer concluded, were long and thin and attracted one another more strongly side to side than end to end. Some substances, like naphthalene and stearic acid, contained layers which could easily slide over one another. That possibly, was also the characteristic of solid lubricants. Rubbing in definite directions increased the tendency to regular arrangements, and pressure increased the tendency to form flakes (*e.g.*, of graphite) parallel to the plane of rubbing. Catalysis would appear to imply the power of a molecule of of the catalyst to draw together the molecules of the gas or liquid on which the catalyst was acting, so that changes could occur in this temporary constrained position which were impossible during ordinary unordered motion.

* The apparatus and method used were illustrated on page 46 of our issue of January 11, 1924.

## LABOUR NOTES.

REPRESENTATIVES of the Engineering and Allied Employers' National Federation and the engineering trade unions resumed the discussion on the wages question at a joint conference in London, on January 16. When the last meeting of the same kind adjourned, it was understood that a sub-committee of the men's delegates would examine the figures relating to the industry's state, submitted by Sir Allan Smith, and prepare a reply to them. Something of the kind was, in fact, attempted. Meetings took place between the sub-committee and the Labour Research Department and an accountant was consulted. Letters were also exchanged by the committee and Sir Allan Smith on points in the employers' economic survey, but the questions raised by the operatives' spokesmen had, it was stated, at the time, little, if any, bearing on the real issue. The speeches of the union delegates at Friday's meeting served to confirm the impression that in Labour circles the state of the industry is not

seriously regarded as a factor. The claim for an advance of 20s. per week was pressed by the different speakers on various grounds, none of which took cognisance of the plain, economic fact that if the employers' figures are accurate—and, so far, they have not been seriously challenged—such an addition to engineering labour costs will be disastrous for both the industry and the people dependent upon it. The representatives of the employers promised to consider the arguments put forward in support of the men's claim, and the conference was adjourned until February 10. Meanwhile, the leaders of the unions are holding mass meetings in the more important provincial centres for the purpose, presumably, of stimulating the interest of the rank and file in the question. Considering that, of late, representative trade unionists have repeatedly stated that they were being strongly urged from below to press the matter, this is odd procedure. Still, the meetings may serve a useful purpose if the delegates care to make clear to the men attending them that from the point of view of employment, insistance on this demand may have a very serious result.

Trade unionists who rarely attend their branch meetings are amongst the best allies the Communist Party has. The aim of this organisation avowedly is to "permeate"—in plainer language, destroy—the existing organisation of labour and put in its place one framed strictly in accordance with rules laid down by Moscow. Its representatives in the trade union branches are not yet a majority, but, as the title of the subsidiary organisation indicates, a minority. They are, however, regular attendants at branch meetings, and many of them are fluent speakers. For their use at sparsely-attended meetings—meetings, that is to say, where they are almost certain to command majorities—the National Minority Movement has now prepared a series of resolutions for submission to the next Trades Union Congress. These resolutions formally call upon the Congress to instruct the General Council to do this, that and the other thing, and, if they are passed by branches and submitted to the higher body, they will assuredly not be without supporters there. Most of the proposed resolutions are political. Here, however, is one to which the majority of organised workers may reasonably take exception:—

"This Congress declares that one of the principal aims of the trade unions is the workers' control of industry. The chaos existing in industry demonstrates the failure of Capitalism to control that industry in a satisfactory fashion. The trade union movement must organise to challenge this control by (1) endeavouring to secure an ever-increasing control over workshop conditions; (2) preparing the trade unions, in conjunction with the party of the workers, to struggle for the overthrow of Capitalism. At the same time Congress warns the workers against all attempts to introduce Capitalist schemes of co-partnership, which, in the past, have failed to give the workers any positive rights, but instead, have usually served as fetters, retarding the forward movement."

In one other respect, trade unionists, who are irregular attendants at branch meetings, or who fail to use their votes in national or district ballots, will be wise, not only in their own interest but also in that of their class, to mend their ways. Within the next few weeks the various unions will elect their representatives to the annual meeting of the Labour Party and also their representatives to this year's Trades Union Congress. That the National Minority Movement will poll its full strength may be taken for granted. Whether the unions are represented by trade unionists or communists, will depend upon the number of level-headed workers who take the trouble to record their votes.

The Ministry of Labour states that the number of persons on the registers of Employment Exchanges in Great Britain on January 12, 1925, was 1,279,800—969,700 men, 39,500 boys, 235,200 women, and 35,400 girls. On January 5, 1925, the number was 1,307,140—998,174 men, 37,788 boys, 238,475 women and 32,703 girls—and on January 14, 1924, it was 1,255,919—927,597 men, 41,250 boys, 247,871 women and 39,201 girls.

The International Transport Workers' Federation states, in an official publication, that reports regarding 6,000 typical American industries show that the number of employed persons in August, 1924, was 17·2 per cent. less than in August, 1923. That means, it says, that during the past year 3½ million workers have lost their jobs. The railways, it is added, have also reduced their staffs by 184,533 persons or about 10 per cent.

According to the January Report of the United Society of Boilermakers and Iron and Steel Shipbuilders, 22,063 members were "signing the books" at the end of December, as compared with 20,673 a month earlier. The expenses in November amounted to 95,374*l.* 15*s.* 10*d.*; in December they were 109,910*l.* 5*s.* 8*d.*—an increase of 14,535*l.* 9*s.* 10*d.*

A Moscow correspondent of the *Soviet Union Review* contributes some interesting information regarding Russia's need of skilled workers. The idea of adopting more rational methods of production is, he says, no longer a debatable question. Nor can there be any doubt, he thinks, about the unlikelihood of carrying through the immense labour involved in developing Soviet Union industry, in the next few years at least, without bringing in outside technical ability. Quite a number of industrial concerns have already invited men from abroad who possess industrial skill and experience, and the practice is, in the opinion of the writer, likely to spread. Although it has the support of the Supreme Economic Council, there are, it is admitted, obstacles to its general adoption, some of which are due to the difficulty of bringing about proper mutual relations with strangers who have been removed to a new sphere of life, and others to the need of creating similar conditions to those to which the strangers have been accustomed at home. Harmonious working with Russian collaborators is also a difficulty.

The opinion which prevails in respect of technical and expert labour is, the writer goes on to say, that if there is to be progress in restoring basic capital, if economy is to be rationalised and labour productivity to advance, scientific and technical assistance must somehow or other be forthcoming. Scientific effort has really never ceased in Russia, but the period of military communism and the conditions then prevailing naturally prevented to a certain degree the getting into touch with specialists and the creation of conditions of intimate fellowship with them. *Ekonomicheskaya Zhizn*, the organ of the Council for Labour and Defence, in dealing with the problem, declares that the Soviet Government must discover a path towards a union with workers of expert ability.

In December, the membership of the Amalgamated Engineering Union decreased from 244,473 to 240,872 A decrease of 562 was also recorded in the number of unemployed members, bringing the total down to 17,192. Reckoned in the society's usual way, the percentage of unemployed is now 7·79.

A week ago we alluded to the attitude of the executive council of the Amalgamated Engineering Union towards the National Minority Movement, and stated that the branches had been warned against appointing delegates to the International Trades Union Unity Conference, which is to be held in London on Sunday. Mr. Smethurst, the general secretary of the A.E.U., in an official communication to the members, directs attention to the fact that the General Council of the Trade Union Congress, which is the only body authorised to act for the trade union movement as a whole in this country, has refused to be represented at the conference. The executive council wish to emphasise, he adds, "that our union has been built up on a democratic basis, viz., by majority rule, and, therefore it must be distinctly understood that no member can officially attend the Minority Conference, and speak in the name of the A.E.U.; further, that the funds of the union cannot be used, nor any levies be raised and charged upon members' cards for the purpose of paying delegates' or any other expenses in connection with this conference."

*The Ministry of Labour Gazette* states that among the 11,500,000 workpeople insured against unemployment under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed at December 22, 1924, was 10·9 compared with 11 at November 24, and with 10·7 at December 21, 1923. Amongst the members of those trade unions from which returns were received the percentage unemployed was 9·2 at the end of December, 1924, compared with 8·6 at the end of November, 1924. The total number of persons registered at employment exchanges in Great Britain and Northern Ireland as unemployed at December 29, 1924, was, approximately, 1,319,000, of whom 1,003,000 were men and 250,000 were women, the remainder being boys and girls. At December 1, 1924, the total was 1,233,000, of whom 942,000 were men and 231,000 were women, and at December 22 it was 1,213,000. At December 21, 1923, it was 1,327,000. Employment was good, on the whole, in the brick and jute trades, in some branches of the cotton trade, and with mill sawyers, and most of the skilled operatives in the building trades. It was fairly good in the carpet and silk trades, with printers and bookbinders, with coopers, and in certain branches of the metal trades. In coal mining and in the wool textile industry, it was slack on the whole. At blast furnaces, at iron and steel works, and in the engineering and shipbuilding trades it continued bad. There was a further improvement in the cotton trade but a decline in the tinplate and pottery industries.

The gradual increase in rates of wages continued in December. In the industries for which statistics are available the changes in rates of wages reported over the month resulted in an aggregate increase of 29,000*l.* in the weekly full-time wages of 500,000 workpeople and in an aggregate reduction of 300*l.* in the weekly wages of nearly 9,000 workpeople. The changes in wages reported in the Department during 1924 resulted in net increases equivalent to over 600,000*l.* in the weekly full-time wages of nearly 3,000,000 workpeople, and in net reductions of over 60,000*l.* in those of nearly 500,000 workpeople. During 1923 there were net reductions of over 3,000,000 workpeople and net increases of 170,000*l.* in the weekly wages of 1,200,000 workpeople. The number of trade disputes involving stoppages of work reported to the Department as beginning in December was 41. In addition 24 disputes which began before December were still in progress at the beginning of the month. The number of workpeople involved in all disputes in December (including workpeople thrown out of work at the establishments where the disputes occurred but not themselves parties to the disputes) was approximately 16,000. The estimated aggregate duration of all disputes during December was about 92,000 working days. The estimated aggregate duration of all disputes reported as in progress during 1924, was about 8,312,000 working days. The total number of workpeople involved in these disputes was 613,000. In the previous year 407,000 workpeople were involved in disputes having an aggregate duration of 10,672,000 working days.

An Emergency Powers Bill, which is to be introduced by the Government in South Africa seeks to provide that the Governor-General may, in the event of strikes and lock-outs threatening disturbances or the suspension of essential services, proclaim a state of emergency in the area affected for a period of one month, the period to be renewable monthly if necessary. The Minister of Labour may appoint a Conciliation Board to effect a settlement of the strike, whose award the Minister may declare to be binding for a period of six months. The employment of blacklegs by employers and threats of violence to non-strikers are prohibited. The Minister and others carrying out the Act, are to be exempted from legal proceedings and from interference by the Courts, providing they do not exceed the powers conferred upon them by the Act.

## THE WORLD'S SHIPBUILDING.

ONLY by the process of stocktaking at regular intervals is it possible to obtain a true estimate of the progress made by any individual firm or by an industry as a whole. Fortunately this method, which is very difficult to apply in many industries, is comparatively simple when dealing with shipbuilding. Indeed, the collecting of the data is performed as a regular activity of Lloyd's Register of Shipping, and is presented in their valuable "Annual Summary of the Mercantile Shipbuilding of the World." In this publication for the year 1924, figures are given for the launches of merchant vessels of 100 gross tons and upwards. From the data provided there can be no doubt that there was a great increase of tonnage launched in the year 1924 as compared with 1923, and as this was due to the improvement in the figures for British yards, it might be concluded that shipbuilding here was now in a vastly improved state. Actually the position must, of course, be viewed purely from an economic standpoint, if any index is to be found as to the existence of a revival of trade. Much of this building has, however, been undertaken at prices which admit of little or no profit and even, in some cases, with a certainty of loss. During the year, which was one in which there was a great amount of unemployment, every effort was made by both the management and the labour sides of the shipbuilding organisations, to accelerate production in order to keep down costs. The statistical statements must, therefore, not be viewed in any sense other than of relationship to the present-day conditions of accepting contracts in the industry for the purpose of keeping the works going and retaining the services of essential workmen until the revival actually comes.

The actual total tonnage of ships launched during 1924 showed a marked increase over the figures for the previous year. Whereas the launches in 1923 numbered 901 and represented 1,643,181 tons, 924 ships left the ways in 1924 and their total tonnage was 2,247,751. These figures show an increase for the year's production of 604,570 tons, but it must not be considered that they reached the figures of the years immediately prior to the European War.

# THE WORLD'S SHIPBUILDING.

## TABLE I.—SHOWING THE NUMBER AND TONNAGE OF MERCHANT VESSELS OF 100 TONS GROSS AND UPWARDS LAUNCHED IN THE VARIOUS COUNTRIES OF THE WORLD DURING THE YEARS 1893–1924.

| Year. | Great Britain and Ireland. | | British Dominions. Coasts. | | British Dominions. Canadian Lake Ports. | | Austria-Hungary. | | Denmark. | | France. | | Germany. | | Holland. | | Italy. | | Japan. | | Norway. | | Sweden. | | United States. Coast. | | United States. Great Lakes. | | Other Countries. | | Totals. | | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No. | Tons. | No | Tons. | |
| 1893 | 526 | 836,383 | 41 | 17,089 | No | Returns | 6 | 7,435 | 18 | 10,719 | 22 | 20,337 | 65 | 60,167 | 8 | 1,339 | 21 | 10,626 | 3 | 1,132 | 30 | 16,552 | 18 | 6,566 | 36 | 27,174 | No | Returns | 42 | 11,222 | 846 | 1,026,741 | 1893 |
| 1894 | 614 | 1,046,508 | 26 | 6,055 | 1 | 748 | 5 | 1,703 | 16 | 7,300 | 28 | 19,636 | 77 | 119,702 | 41 | 15,360 | 10 | 5,396 | 14 | 3,173 | 25 | 17,169 | 14 | 7,310 | 36 | 44,847 | 7 | 22,047 | 18 | 6,584 | 932 | 1,323,538 | 1894 |
| 1895 | 579 | 950,967 | 23 | 6,105 | 7 | 4,276 | 10 | 71 | 14 | 10,982 | 27 | 28,851 | 75 | 87,786 | 25 | 8,292 | 10 | 5,603 | 3 | 2,296 | 21 | 12,873 | 13 | 2,767 | 41 | 42,431 | 20 | 42,446 | 12 | 5,114 | 880 | 1,218,160 | 1895 |
| 1896 | 696 | 1,159,751 | 36 | 8,394 | 5 | 2,730 | 9 | 6,246 | 14 | 11,814 | 41 | 44,565 | 63 | 103,295 | 28 | 12,405 | 10 | 6,779 | 26 | 7,849 | 17 | 12,059 | 14 | 4,405 | 112 | 77,964 | 32 | 106,211 | 10 | 3,415 | 1,113 | 1,567,882 | 1896 |
| 1897 | 591 | 952,486 | 36 | 10,489 | 4 | 1,942 | 6 | 6,601 | 13 | 13,539 | 39 | 49,341 | 84 | 139,728 | 42 | 20,351 | 8 | 12,910 | 22 | 6,740 | 25 | 17,248 | 14 | 6,984 | 63 | 34,076 | 21 | 52,762 | 22 | 6,727 | 990 | 1,331,924 | 1897 |
| 1898 | 761 | 1,367,570 | 65 | 22,664 | 5 | 2,357 | 9 | 5,432 | 17 | 12,703 | 48 | 67,160 | 104 | 153,147 | 27 | 19,468 | 19 | 26,530 | 9 | 11,424 | 29 | 22,670 | 12 | 4,385 | 141 | 110,186 | 21 | 63,064 | 23 | 4,583 | 1,290 | 1,893,343 | 1898 |
| 1899 | 726 | 1,416,791 | 31 | 6,475 | 3 | 1,989 | 8 | 9,248 | 30 | 26,613 | 51 | 89,794 | 93 | 211,684 | 50 | 34,384 | 31 | 49,472 | 3 | 6,775 | 34 | 27,853 | 29 | 10,367 | 127 | 146,108 | 21 | 78,170 | 32 | 6,015 | 1,289 | 2,121,738 | 1899 |
| 1900 | 692 | 1,442,471 | 38 | 6,967 | 2 | 2,596 | 12 | 14,889 | 17 | 11,060 | 66 | 116,858 | 93 | 204,731 | 41 | 45,074 | 36 | 67,522 | 3 | 4,543 | 42 | 32,751 | 19 | 5,735 | 196 | 190,962 | 39 | 142,565 | 48 | 15,439 | 1,364 | 2,304,163 | 1900 |
| 1901 | 639 | 1,524,739 | 68 | 16,610 | 6 | 11,524 | 7 | 20,013 | 41 | 22,856 | 92 | 177,543 | 101 | 217,593 | 33 | 29,927 | 35 | 60,526 | 94 | 37,208 | 40 | 36,875 | 31 | 8,241 | 234 | 268,091 | 52 | 165,144 | 65 | 20,649 | 1,538 | 2,617,539 | 1901 |
| 1902 | 694 | 1,427,558 | 65 | 18,235 | 4 | 10,584 | 16 | 15,192 | 44 | 27,148 | 99 | 192,196 | 108 | 213,961 | 114 | 69,101 | 62 | 46,270 | 53 | 27,181 | 46 | 37,878 | 32 | 9,030 | 206 | 223,360 | 45 | 155,814 | 62 | 29,247 | 1,650 | 2,502,755 | 1902 |
| 1903 | 697 | 1,190,618 | 64 | 20,866 | 9 | 13,824 | 6 | 11,328 | 39 | 28,609 | 75 | 92,768 | 120 | 184,494 | 109 | 59,174 | 81 | 50,089 | 62 | 34,514 | 54 | 41,599 | 30 | 11,855 | 195 | 211,219 | 51 | 170,601 | 58 | 24,073 | 1,650 | 2,145,631 | 1903 |
| 1904 | 712 | 1,205,162 | 55 | 27,253 | 6 | 3,712 | 40 | 16,645 | 30 | 15,859 | 69 | 81,245 | 149 | 202,197 | 109 | 55,636 | 35 | 30,016 | 67 | 32,969 | 67 | 50,469 | 32 | 10,267 | 208 | 189,430 | 19 | 49,088 | 45 | 17,987 | 1,643 | 1,987,935 | 1904 |
| 1905 | 795 | 1,623,168 | 45 — 10,798 | | | | 27 | 16,402 | 19 | 17,557 | 43 | 73,124 | 148 | 255,423 | 58 | 44,135 | 46 | 61,629 | 81 | 31,725 | 58 | 52,580 | 20 | 5,282 | 157 | 107,368 | 43 | 195,459 | 36 | 20,272 | 1,576 | 2,514,922 | 1905 |
| 1906 | 886 | 1,828,343 | 50 | 16,026 | 7 | 10,016 | 25 | 18,590 | 18 | 24,712 | 48 | 35,214 | 205 | 318,230 | 89 | 66,809 | 30 | 30,560 | 107 | 42,489 | 69 | 60,774 | 23 | 11,579 | 192 | 169,358 | 50 | 271,729 | 37 | 15,334 | 1,836 | 2,919,763 | 1906 |
| 1907 | 841 | 1,607,890 | 83 | 21,479 | 14 | 24,964 | 7 | 8,717 | 29 | 28,819 | 50 | 61,635 | 188 | 275,003 | 60 | 68,623 | 31 | 44,666 | 78 | 66,254 | 82 | 57,556 | 28 | 11,781 | 208 | 217,530 | 47 | 257,145 | 42 | 28,026 | 1,788 | 2,778,088 | 1907 |
| 1908 | 523 | 929,669 | 111 | 25,512 | 8 | 8,669 | 24 | 23,502 | 24 | 19,172 | 50 | 83,429 | 120 | 207,777 | 76 | 58,604 | 34 | 26,864 | 73 | 59,725 | 81 | 52,839 | 23 | 9,546 | 202 | 158,645 | 36 | 145,898 | 20 | 23,435 | 1,405 | 1,833,286 | 1908 |
| 1909 | 526 | 991,066 | 35 | 6,592 | 3 | 869 | 15 | 25,006 | 11 | 7,508 | 51 | 42,197 | 84 | 128,696 | 52 | 59,106 | 28 | 31,217 | 75 | 52,319 | 45 | 28,601 | 12 | 6,316 | 73 | 80,485 | 29 | 129,119 | 24 | 12,960 | 1,063 | 1,602,057 | 1909 |
| 1910 | 500 | 1,143,169 | 53 | 14,601 | 7 | 11,742 | 8 | 14,304 | 18 | 12,154 | 55 | 80,751 | 117 | 159,303 | 105 | 70,945 | 21 | 23,019 | 70 | 30,215 | 64 | 36,931 | 17 | 8,904 | 156 | 177,601 | 39 | 153,717 | 47 | 20,497 | 1,277 | 1,957,853 | 1910 |
| 1911 | 772 | 1,803,844 | 59 | 16,006 | 3 | 3,656 | 16 | 37,836 | 18 | 18,689 | 79 | 125,472 | 154 | 255,532 | 113 | 93,050 | 14 | 17,401 | 109 | 44,359 | 71 | 35,435 | 11 | 9,427 | 112 | 95,693 | 30 | 75,876 | 38 | 17,864 | 1,599 | 2,650,140 | 1911 |
| 1912 | 712 | 1,738,514 | 76 | 25,090 | 8 | 9,700 | 12 | 38,821 | 22 | 26,103 | 80 | 110,734 | 165 | 375,317 | 112 | 99,439 | 27 | 25,196 | 168 | 57,755 | 89 | 50,255 | 22 | 13,968 | 144 | 194,273 | 30 | 89,950 | 52 | 46,654 | 1,719 | 2,901,769 | 1912 |
| 1913 | 688 | 1,932,153 | 77 | 26,744 | 14 | 21,595 | 17 | 61,757 | 31 | 40,932 | 89 | 176,095 | 162 | 465,226 | 95 | 104,296 | 38 | 50,356 | 152 | 64,664 | 74 | 50,637 | 25 | 18,524 | 182 | 228,232 | 23 | 48,216 | 83 | 43,455 | 1,750 | 3,332,882 | 1913 |
| 1914 | 656 | 1,683,553 | 58 | 22,288 | 22 | 25,246 | 11 | 34,335* | 25 | 32,815 | 33 | 114,052 | 89 | 387,192* | 130 | 118,153 | 47 | 42,981 | 32 | 85,861 | 61 | 54,204 | 26 | 15,163 | 84 | 162,937 | 10 | 37,825 | 35 | 36,148* | 1,319 | 2,852,753* | 1914 |
| 1915 | 327 | 650,919 | 27 | 13,289 | 4 | 8,725 | No | Returns | 23 | 45,198 | 6 | 25,402 | No | Returns | 120 | 113,075 | 30 | 22,132 | 26 | 49,408 | 59 | 62,070 | 27 | 20,319 | 76 | 157,167 | 8 | 20,293 | 10 | 13,641* | 743 | 1,201,638* | 1915 |
| 1916 | 306 | 608,235 | 36 | 22,577 | 4 | 8,994 | No | Returns | 28 | 35,277 | 9 | 42,752 | No | Returns | 201 | 180,197 | 10 | 56,654 | 55 | 145,624 | 52 | 42,458 | 34 | 26,769 | 167 | 384,899 | 44 | 119,348 | 18 | 14,296* | 964 | 1,688,080* | 1916 |
| 1917 | 286 | 1,162,896 | 80 | 66,475 | 25 | 27,996 | No | Returns | 23 | 20,445 | 6 | 18,828 | No | Returns | 146 | 148,779 | 11 | 38,906 | 104 | 350,141 | 44 | 46,103 | 34 | 26,760 | 266 | 821,115 | 60 | 176,804 | 27 | 32,538* | 1,112 | 2,937,786* | 1917 |
| 1918 | 301 | 1,348,120 | 184 | 230,514 | 22 | 49,390 | No | Returns | 13 | 26,150 | 3 | 13,715 | No | Returns | 74 | 74,026 | 15 | 60,791 | 198 | 489,924 | 51 | 47,723 | 36 | 39,583 | 741 | 2,602,153 | 188 | 430,877 | 40 | 34,478* | 1,866 | 5,447,444* | 1918 |
| 1919 | 612 | 1,620,442 | 235 | 298,495 | 28 | 60,233 | — | — | 46 | 37,766 | 34 | 32,663 | * | * | 100 | 137,086 | 32 | 82,713 | 133 | 611,883 | 82 | 57,578 | 53 | 50,971 | 852 | 3,579,826 | 199 | 495,559 | 77 | 79,334 | 2,483 | 7,144,549* | 1919 |
| 1920 | 618 | 2,055,624 | 90 | 174,557 | 13 | 29,087 | — | — | 30 | 60,669 | 50 | 93,449 | * | * | 99 | 183,149 | 82 | 133,190 | 140 | 456,642 | 30 | 38,855 | 46 | 63,823 | 467 | 2,348,725 | 42 | 127,528 | 52 | 96,368 | 1,759 | 5,861,666* | 1920 |
| 1921 | 426 | 1,538,052 | 49 | 118,303 | 5 | 11,372 | — | — | 37 | 77,238 | 65 | 210,663 | 242 | 509,064 | 98 | 232,402 | 85 | 164,748 | 43 | 227,425 | 35 | 51,458 | 27 | 65,911 | 166 | 995,129 | 7 | 11,284 | 92 | 128,630 | 1,377 | 4,341,679 | 1921 |
| 1922 | 235 | 1,031,081 | 37 | 53,347 | 2 | 9,418 | — | — | 23 | 41,016 | 62 | 184,509 | 195 | 575,264 | 60 | 163,132 | 42 | 101,177 | 49 | 83,419 | 23 | 32,391 | 14 | 30,038 | 55 | 97,161 | 4 | 21,977 | 51 | 43,154 | 852 | 2,467,084 | 1922 |
| 1923 | 222 | 645,651 | 41 | 37,072 | 3 | 4,191 | — | — | 24 | 49,479 | 27 | 96,644 | 117 | 358,273 | 35 | 65,832 | 21 | 66,523 | 44 | 72,475 | 48 | 42,619 | 10 | 20,118 | 69 | 96,491 | 14 | 76,326 | 26 | 11,687 | 701 | 1,643,181 | 1923 |
| 1924 | 494 | 1,439,885 | 29 | 29,815 | 2 | 15,064 | — | — | 33 | 63,937 | 26 | 79,685 | 116 | 193,952 | 41 | 63,627 | 19 | 82,526 | 31 | 72,757 | 34 | 25,139 | 12 | 31,211 | 71 | 90,155 | 8 | 49,303 | 8 | 10,690 | 924 | 2,247,751 | 1924 |

* Returns not complete.

Of course, the year 1913 was an exceptional one, for then the pre-war record for tonnage was established, and it cannot therefore be taken as any indication of what might be regarded as a normal year. But in 1911 and 1912, the world's production of tonnage was 402,389 tons and 654,018 tons, respectively, more than the figure for 1924. Building of any extensive character cannot be anticipated while the excess of tonnage exists, unless in special classes of vessels. In June, 1914, the world's mercantile tonnage amounted to 42,514,000 tons, while in June of last year the figure reached 57,530,000 tons, an increase of over 15 million tons. Of all this shipping, some 6 million, or more, tons are laid up, but over two-thirds of this idle tonnage belongs to the United States. For the last six months the laid-up British tonnage has been decreased from 700,000 tons to 570,000 tons.

The Lloyd's Register Quarterly Returns show the change in conditions every three months, and from them it may be noted that at the commencement of 1924 there were 2,444,000 tons of shipbuilding in course of construction. There was a steady increase until the end of June, since when there has been a marked decrease. At the end of the year, the tonnage under construction in the world amounted to 2,470,000 tons, or a net increase of 26,000 tons. This balance is obtained by the difference of the increase abroad of 124,000 tons and the decrease of 98,000 tons in Great Britain and Ireland.

Some interesting facts may be gathered from the Summary in regard to machinery. Of the total launches during the year, there were 32 included which will be propelled by steam turbines. Their tonnage totals no less than 284,700 tons, and thus the average works out at 8,895 tons. The increase in the tonnage of new construction in which internal-combustion engines are used for propulsion, continued during the year. In 1924 there was launched 501,798 tons of such ships, which contrasts well with the figure of 226,040 tons for 1923. For 1924 the oil engine-propelled vessels represented 29¼ per cent. of the world's total output of steam tonnage. In 1923 this figure was 16¼ per cent. At the present time the motor-ships under construction have attained the position of amounting to over 60 per cent. of the total tonnage of steam-propelled vessels building, which shows the remarkable development which is taking place. Construction for the larger types of vessels is now undertaken, and in the collection of the 10 largest vessels launched during the year it will be noted that two, the Aorangi and the Gripsholm, have oil engines for their propulsion.

TABLE II.—*Showing the Number and Tonnage of Merchant Vessels Launched in the Principal Shipbuilding Districts in Great Britain and Ireland during the Years* 1922–1924.

| District. | Total 1922. No. | Total 1922. Tons. (Gross.) | Total 1923. No. | Total 1923. Tons. (Gross.) | Total 1924. No. | Total 1924. Tons. (Gross.) |
|---|---|---|---|---|---|---|
| Aberdeen .. .. | 3 | 3,390 | 6 | 4,231 | 18 | 14,323 |
| Barrow, Maryport and Workington | 3 | 21,342 | 2 | 2,986 | 10 | 42,538 |
| Belfast and Londonderry .. | 12 | 94,019 | 12 | 129,332 | 14 | 109,194 |
| Dundee .. .. | 9 | 31,552 | 5 | 21,282 | 8 | 20,961 |
| Clyde— | | | | | | |
| Glasgow .. | 51 | 270,630 | 39 | 132,239 | 105 | 360,602 |
| Greenock .. | 21 | 121,429 | 13 | 40,962 | 48 | 171,470 |
| Hartlepools .. | 4 | 18,822 | 5 | 23,864 | 14 | 55,804 |
| Hull .. .. | 9 | 2,200 | 10 | 17,311 | 41 | 19,500 |
| Leith .. .. | 4 | 8,193 | 10 | 8,782 | 14 | 24,300 |
| Liverpool .. .. | 5 | 12,189 | 6 | 21,044 | 16 | 38,571 |
| Middlesbro', Stockton and Whitby | 17 | 45,814 | 23 | 42,709 | 56 | 105,707 |
| Newcastle .. .. | 42 | 240,788 | 44 | 137,408 | 76 | 275,672 |
| Sunderland .. | 27 | 126,713 | 17 | 51,561 | 56 | 194,075 |

Great Britain and Ireland.—During the year 1924, there were launched in Great Britain and Ireland 494 merchant vessels totalling 1,439,885 tons. Of these, 423 were steamers, 50 were motor-ships, and 21 were barges. This total tonnage represents 64·1 per cent. of the world's output for the year. When this is compared with the value of 39·2 per cent. which held in 1923, 41·8 per cent. in 1922 and 58 per cent. in 1913, it is apparent that the British shipbuilders are not falling off in their share of the total activity, but all are suffering from the excess of tonnage which is already available. It has previously been indicated that there were 98,000 tons less shipbuilding work in hand in Great Britain and Ireland at the end of 1924 than in the beginning of that year. The totals for 1923, however, included about 164,000 tons on which work had been suspended, and this total was decreased during the year 1924 to 60,000 tons. As tonnage has been launched, its place has not been taken by new construction, and consequently, any marked improvement in the condition of the industry cannot be expected in the immediate future.

Of the vessels built at home, 15½ per cent. of the tonnage was built to foreign orders. A comparison of this figure with those for other years, enables an estimate of the trend of this phase of overseas trade to be formed. In 1923, only 3 per cent. of the tonnage was built for export, while in 1922 the figure was 26 per cent. and for the five pre-war years, 1909 to 1913, the average was 22 per cent.

The ten largest vessels built during 1924 were of British construction. At the head of the list is the ss. Statendam, of 28,150 tons, which was built by Messrs. Harland and Wolff, of Belfast, who also constructed the ss. Minnetonka, of 21,998 tons, for the Atlantic Transport Company, Limited. For the Orient Steam Navigation Company, Limited, Messrs. John Brown and Co., Limited, built the ss. Oronsay, which has twin screws and turbines of 20,000-h.p. A sister ship, the ss. Orama, was completed by Messrs. Vickers Limited, at Barrow-in-Furness, and is now also in service. Both of these vessels are of about 19,800 tons. Proceeding down the list in order of magnitude, we find the ss. De Grasse, built by Messrs. Cammell Laird and Co., Ltd., of Birkenhead. This vessel will be registered at Havre, and is 17,962 tons gross, and for propulsion is provided with turbines of 13,000-h.p. The Aorangi and the Gripsholm represent the large motor-ship class. Of these, the former was built by the Fairfield Shipbuilding and Engineering Company, Limited, of Govan, and the latter by

Sir W. G. Armstrong, Whitworth and Co., Limited, of Walker-on-Tyne. The three remaining vessels of 15,000, or more, tons, are the Rampura, built by Messrs. R. and W. Hawthorn, Leslie and Co., Limited, Hebburn-on-Tyne, and the Cathay and Comorin, both productions of Messrs. Barclay, Curle and Co., Limited, Glasgow. Six ships of between 10,000 and 15,000 tons were also constructed, and the next class contains no less than 75 ships of between 5,000 and 10,000 tons. Table II, on the previous page, shows the number and total tonnage of merchant vessels launched in different districts during the last three years, from which it will be obvious that the River Clyde takes first place not only in the total tonnage—532,072 tons—but also in the magnitude of the change of conditions from 1923. Increased production was also recorded in all the other British shipbuilding centres with the exception of Belfast and Londonderry, and of Dundee.

The British Dominions Overseas contributed 44,879 tons of shipping during 1924, of which 15,864 tons were launched in Canada, 12,690 tons at Hong Kong, and 11,751 tons in Australia. Three of the vessels included in these figures have a tonnage of over 3,000 each. These are the Ferndale, of 9,700 tons, built at Sydney, New South Wales, and one of 7,900 tons, and another of 7,164 tons, built at Midland, Ontario, and Collingwood, Ontario, respectively.

*Other Countries.*—In Table I is given, for purposes of easy comparison, a statement of the number of ships built and their total tonnage for the most important shipbuilding countries of the world for each year from 1893. During the year 1924 there were 430 merchant vessels of 807,866 tons launched abroad. Of these, 266 were steamers and accounted for 503,727 tons of the total production, while there were 99 motor vessels of 264,340 tons and 65 sailing vessels and barges of 39,799 tons. These figures show a total decrease of 189,664 tons as compared with 1923 and of 4,716,241 tons as compared with 1919—the record year. The largest vessel built abroad during 1924 was the ss. D'Artagnan, of 14,700 tons, which was constructed at Bordeaux. Of the 99 motor vessels built abroad, 27 were of over 4,000 tons, including 11 in Germany and four each in Denmark and Italy. The two largest motor ships were of about 13,600 tons each and were built in Germany.

*Germany.*—This country launched 116 vessels of 193,952 tons in 1924. It may be said that these figures, for the purpose of comparison with former years, include eight vessels of 18,839 tons launched at Danzig. As compared with the figures for 1923, the tonnage launched in 1924 was 164,321 tons less, but nevertheless it represents 24 per cent. of the total output abroad. Not a single vessel included in the 1924 figures was fitted with steam turbines, but there were 29 vessels, of 99,741 tons, fitted with oil engines. This was nearly 38 per cent. of the total motor tonnage built abroad during the year and included in these figures were three vessels of between 10,000 and 14,000 tons each.

*United States.*—The total output for the United States of America for 1924, amounting to 139,463 tons, was 33,354 tons less than the figure for 1923, and about 3,936,000 tons less than that for the record year of 1919. With the exception of 1922, last year was the worst experienced in shipbuilding in the United States since 1897. The total figures include two steamers of 6,000 and 8,000 tons, each launched on the coast, and five vessels of between 8,000 and 9,000 tons constructed on the Great Lakes. There were 39,333 tons of motor tonnage added in the year and 16,197 tons of tankers. It is of interest to note that the American building programme included five vessels with a total tonnage of 1,567 tons, which will have oil engines and electric driving for the final part of the transmission system.

*Italy.*—The figures for this country are 82,526 tons, or actually 16,003 tons more than in 1923. In the Trieste district the greatest increase occurred, for six vessels were built there which had a tonnage of 32,557, although in 1923 the total output did not exceed 7,515 tons. The totals included 12 vessels of between 5,500 and 8,500 tons each, and there were six turbine vessels launched which have a total tonnage of 38,964 as well as six motor-ships of 28,708 tons.

*France.*—A decrease of 13,959 tons is shown in the comparison of the last two years' returns for France. The 1924 total tonnage of 79,685 tons was nearly 58,000 tons below the average of the last three pre-war years. The D'Artagnan, the largest vessel launched abroad during the year, was of 14,700 tons, and was constructed at Bordeaux. It is of interest to note that not a single vessel fitted with steam turbines or oil engines was launched in France during the whole of last year.

*Holland.*—The figure for Holland's output—63,627 tons—was 2,000 tons less than in 1923, and the lowest recorded since 1909. Much higher figures would be given for Holland if the vessels intended exclusively for river navigation were included in the totals.

*Japan.*—The Japanese position remained practically the same as in 1923, and the tonnage produced exceeded that for any year prior to 1914. Last year's figures included four vessels of between 5,600 and 8,600 tons each, one of which was turbine driven and another had oil engines.

*Conclusion.*—Of the merchant vessels launched during 1924, 468 ships, making a total of 1,435,435 tons, were built under the survey of Lloyd's Register of Shipping with a view to receiving their classification. These figures include 82·6 of the total output of Great Britain and Ireland, while a total of 79 vessels built abroad during the year were also included in the surveys of Lloyd's. The magnitude of the work of the organisation may be judged from the inclusion of a chart in the Annual Summary which shows that no less than 30 million tons of the world's mercantile marine, or something over 60 per cent. of the total launched in the last 15 years, have been built to the requirements of Lloyd's Register.

## THE LATE MR. E. P. SEATON.

WE regret to announce the death of Mr. Edward Park Seaton, who played an important part in the construction of some of the tube railways of London. Mr. Seaton died on Tuesday, January 13, at Newtown, Hayling Island.

He entered on his engineering career in 1869, when he was articled to Mr. John Ramsbottom, the locomotive superintendent of the London and North Western Railway. Later he worked under Mr. William Morton on the construction of the Liverpool Central Station and the Liverpool North Extension Railway. In 1881 he was appointed resident engineer, under Mr. Joseph Tomlinson, the engineer of the Metropolitan Railway, and was engaged on the construction of the city lines from Aldgate to Trinity-square. From 1883 to 1885 he was resident engineer under Sir John Hawkshaw and Mr. (late Sir) John Wolfe Barry on the part of the line from Trinity-square to Mansion House. From 1885 he was acting engineer for the Metropolitan Railway Company, and amongst other work he carried out the alterations at Baker-street and other stations, and constructed the subway connecting the Metropolitan Railway with King's Cross station. He also built the Cranbrook and Paddock Wood branch of the South Eastern Railway. Mr. Seaton was elected an Assoc.M.Inst.C.E. in 1881 and was transferred to the class of Member in 1892.

## THE LATE MR. WILLIAM LEES.

WE note, with regret, the death of Mr. William Lees, the managing director of Messrs. T. and R. Lees, Limited, of Hollinwood, Oldham, which occurred at his residence, Vale House, Vicarage-street, Hollinwood, Lancashire, on Wednesday, January 7. Mr. Lees was the son of the founder of the firm with which he received his training and spent the whole of his professional career. He was educated privately in Hollinwood and on the Continent, and on entering the firm took technical classes in Oldham, and later in Manchester. In the course of his training Mr. Lees spent a considerable amount of time in the pattern shop and foundry in addition to that spent in the machine shop and drawing office. In consequence of the earnestness which he showed at this period in his work, he acquired a training which stood him in good stead when he became chief draughtsman in 1891, works manager in 1894, and general manager in 1908. In the course of his career he designed many engines for electric power plants and for driving works, both at home and abroad, in addition to air compressors and woodworking machinery, which served greatly to enhance the reputation of the firm.

Mr. Lees was a member of the Institution of Mechanical Engineers and of the Manchester Association of Engineers.

VISIT TO ENGLAND OF SOUTH AFRICAN ENGINEERING STUDENTS.—In a note appearing in our issue of January 9, referring to the visit of the South African engineering students to England, it was stated that "Messrs. Merz and McLellan are to act as hosts to the party when they visit Newcastle-upon-Tyne." The actual position is that the official hosts for this part of the tour are the Newcastle Corporation and the Durham University, and we, therefore, correct the former misstatement.

PERSONAL.—At the recent annual meeting of Wailes Dove Bitumastic, Limited, Mr. E. J. Dove resigned his position of managing director, and Mr. Charles Macdonald resigned his position as assistant managing director. These gentlemen's services are still retained as directors of the company, however and Mr. W. H. Dick, who has been for some years assistant managing director, was appointed managing director of the company.—Senatore G. Marconi has been elected an honorary member of the Institution of Civil Engineers.

## THE REPAIR OF WATERLOO BRIDGE.

IN our issue of December 12, 1924, page 807, we recorded the fact that the London County Council had approached the Council of the Institution of Civil Engineers in order to obtain the assistance of that body with a view to arriving at a decision as to the best means to adopt in connection with Waterloo Bridge. We pointed out at the time that two eminent members of the Council of the Institution had already reported on the matter, and from the letter which has now been addressed to the London County Council, reproduced below, it will be seen that the advice tendered recommends the acceptance of the opinion of Mr. Basil Mott and the late Sir Maurice Fitzmaurice against underpinning. It is difficult to see what other course could very well have been taken, either in view of the varied composition of the council of the Institution, or the eminent position of these two engineers in the Institution, or of the Council's relation to the engineering profession. It is an essential feature of our institutions that they take no direct part in actual professional work.

The Institution of Civil Engineers,
Great George-street,
Westminster, S.W. 1.
January 14, 1925.

To Sir James Bird,
Clerk of the London County Council,
County Hall, S.E. 1.

SIR,—In reply to your letter of December 10, 1924, I have been directed to say that the Council of the Institution of Civil Engineers much appreciate being asked by the London County Council to express "their views on the question whether, having regard to the present condition of Waterloo Bridge, it would be practicable and reasonable to underpin all or some of the piers of the bridge so as to render the structure permanently safe and to enable it to be restored to its original form."

Whilst it is not within the province of the Institution Council to give a technical opinion on such a question, they desire, having regard to the public importance of this matter, to afford the London County Council such assistance as is within their power. The Institution Council have therefore given their most careful consideration to the subject.

In the result they are of opinion that the London County Council have followed the best possible course in consulting two engineers of acknowledged eminence in this particular branch of engineering.

It is observed that these engineers, after careful examination of all the essential details of the case, have reported unfavourably as to underpinning.

It is the view of the Institution Council that the London County Council would be well advised to act on the considered individual opinion of these consultants.

I am, Sir, your obedient servant,
(Signed) H. H. JEFFCOTT, Secretary.

The receipt of this letter was reported at the County Council meeting on Tuesday last, the supplementary agenda bearing the following statement on behalf of the Special Committee on Thames Bridges :—

We feel that the Council is greatly indebted to the Council of the Institution for the assistance which they have given so readily in this important and difficult matter and for the promptness with which that assistance has been rendered. We have caused a letter to be sent to the Council of the Institution expressing the Council's high appreciation of the public spirit which has induced them to give an opinion in the matter.

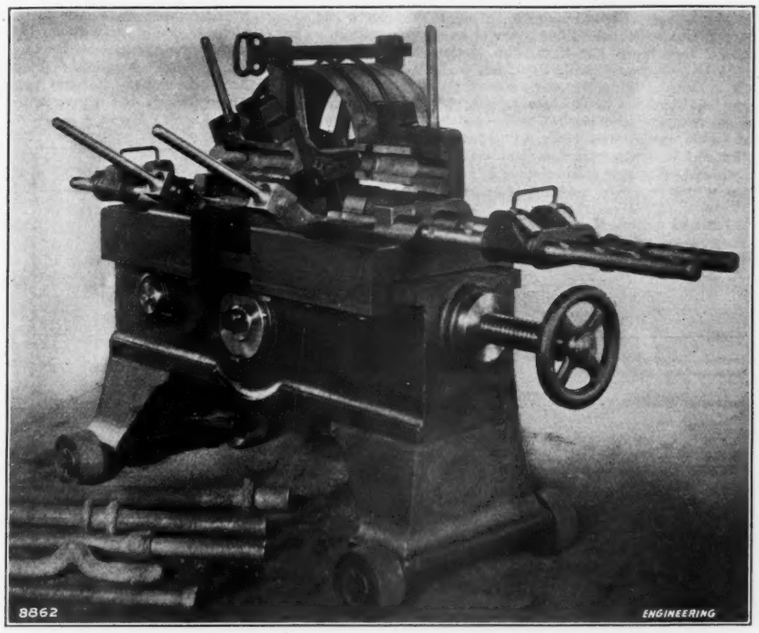
R. C. NORMAN, Chairman.

January 19, 1925.

STATISTICS OF TIN.—The total supply of tin available on December 31, 1923, was 28,311 tons, in which figure was included 9,680 tons of pooled Eastern tin stocks in connection with the Bandoeng Agreement, providing for the controlled release of accumulated quantities of the metal. On December 31, 1924, the pooled Eastern stocks had been completely disposed of, and the total supply of tin available was 23,160 tons, a decrease during the twelve months of 5,151 tons.

ELECTRICAL TRANSMISSION AT 150,000 VOLTS.—On Friday, January 16, Major A. M. Taylor read a paper on "The Hexaphase System and the Compensated Three-phase System for 150,000-Volt Transmission, with Records of Tests." In the system of working due to Major Taylor use was made of the external conductors to carry supplies from tappings on the transformers, while the full voltage was only applied to the inner core. Claims were made for the system that it permitted the construction of a very high tension cable with low potential differences across each layer of insulation and of reasonable outside diameter. The paper contained some information on tests which had been made by the author on a length of triple concentric cable, which was designed to stand 150,000 volts, and the results from these were compared with information relating to two three-core cables which were recently manufactured. Comparisons were also made with a design for a 100,000-volt three-core cable and a single core 100,000-volt cable. One of the claims made by Major Taylor was that because of the distribution of stress over the dielectric being better than was obtained in other designs, higher voltages could be applied to cables of ordinary sizes.

## COLLAR AND HEAD PRESS.




### COLLAR AND HEAD PRESS.

A TOOL which should prove of very considerable value in many classes of engineering work is illustrated in the figure above. It is intended for forming collars or heads of any shape on spindles, axles, bolts, &c. The machine is rapid in operation and the smallest size in which it is built, which can deal with material up to 1 7/16 in. diameter, can produce formed pieces at rates up to 120 per hour. The largest size machine which deals with material up to 3¼ in. diameter has an output of 60 pieces an hour. The machine consists of a main bed carrying a stationary and a moving head. The stationary head is adjustable on the bed, to suit the particular job being dealt with, by means of the hand wheel and screw which can be seen at the right-hand side of the figure. The moving head is reciprocated by means of a crank driven from the belt pulley through double-reduction spur gearing. Each head is furnished with a hinged upper member, which may be lifted as shown in the illustration for the insertion of the job. When this is in place in the dies the heads are closed and are locked in position by the cam levers, which are carried at the front of the machine.

The collar is formed on the work by means of the removable dies carried by the heads. These can be seen in the figures, the die grooves being made to the shape of the collar required. Formation of the collar is carried out at a single heat and in a single operation. Taper or other specially shaped collars may be formed without difficulty by inserting appropriate dies, while plain collars may be formed between the dies and in this case a somewhat larger collar may be produced. The travel of the moving head is constant, and the effective upset required to form the particular collar which is being produced is obtained by allowing a certain amount of lost motion. This is effected by adjustment of the stops provided for the two heads.

As will be seen from the illustration, these stops are each carried on two horizontal rods which are formed with grooves in the upper sides to furnish a rough adjustment for the stops. Fine adjustment is provided by screws working in the stops and fitted with handwheels. These screws bear against the end of the work. The smaller machine dealing with work up to 1 7/16 in. diameter can form collars ⅜ in. deep in the dies, and up to 2¼ in. deep and ⅜ in. long between them. The corresponding figures for the larger 3¼ in. machine are 2¼ in. in the dies and 5¾ in. by 1¼ in. between them. The stroke of the moving head of the smaller machine is 3 in. and of the larger 4¼ in. The power required for driving in the two cases being 2 to 3 h.p. and 4 to 5 h.p. The machine is placed on the market in this country by Mr. O. E. Meyer, of 3 & 5, New Street, Old-street, London, E.C.1.

### THE FLETTNER ROTOR SHIP.*

*The Utilisation of Aerodynamical Knowledge for the Propulsion of Ships by Wind.*

By VON AUTON FLETTNER.

AFTER my rudder for aircraft and ships had been brought to a state of practical development, I occupied myself with the furtherance of my principle of the control of large surfaces by means of a small one for the wind propulsion of ships. My original idea was to substitute metal for canvas sails, built like the wings of modern aircraft. These were to be pivoted like a weather-cock, in a precisely similar manner to my rudder, and controlled by a steering surface. The theoretical data available on the subject of sails was very primitive and in many respects even incorrect. As I was seeking to produce an improved sailing device, I had to begin by exploring the effect of the wind upon ordinary sails. I therefore started a research in the Göttingen Aerodynamic Experimental Laboratory, first with models of canvas sails and later on with metal sails.

As a result of these experiments, a definite improvement was shown to be possible by the use of metal bodies controlled by pilot surfaces, in place of sails. The arrangement involved, however, a large area of metal surfaces by which the construction was complicated. For this reason I was not satisfied with the results and looked round for further possibilities. Thus, among other things, experiments were conducted on the feasibility of a wind turbine, the sails of which would be adjusted by my steering system. The practical application of an idea of Prandtl was suggested by the managers of the aero-dynamical experimental laboratory of Göttingen University, Dr. Betz and Herr Ackeret, by which the efficiency of the driving bodies would be increased by the induction of the "boundary layer."

In this field also, I had various experiments made, which showed that even greater difficulties lay in the way of a practical solution of the sail problem in that direction. The difficulties involved in the use of large steerable wings, with regard to their behaviour in gales, reduced the problem to one of finding the simplest possible arrangement which would be unaffected by storms. In the beginning of 1922, I was already occupied with the idea of producing artificially a circulation in the current round surfaces of symmetrical section, fixed immovably to the ship. The ship would be steered by altering the direction of circulation of this artificially-induced current. I covered this idea with a German patent on September 17, 1922. While working in this field, I conceived the idea to use as sails fixed surfaces round which a skin was rotated. I thought first of two rollers which would be combined with a rotating skin; later of the single cylinder. I was strengthened in my opinion when, at the end of 1922, I read Professor Föttinger's work "New Bases for the Theoretical and Experimental Treatment of Propeller Problems." The consideration that special machinery would be necessary to produce the rotation had first of all restrained me from using the idea and patenting it.

In 1853 the eminent physical experimentalist Magnus, in Berlin, published his discovery in "Poggendorf's Annals," under the title "The Drift of Shells." Magnus carried out his experiments on the effect of the wind on projectile-shaped bodies, principally from the point of view of ballistics. A shell, rotated by the rifled gun-barrel, is affected by a side wind directly its axis ceases to coincide with the tangent of its trajectory. Through the effect of its rotation, this side wind brings into play the above-mentioned transverse force, perpendicular to the trajectory, which is very annoying to the gunner. Magnus had established by his experiments that a rotating, cylindrical body blown upon at right angles to its axis by a wind, not only offers the usual resistance, but also receives a force directed towards that side of it on which the relative wind speed and peripheral speed are most nearly equal. Lord Rayleigh has dealt with similar phenomena in tennis balls, in a short essay on "The Irregular Flight of a Tennis Ball." He mentions that a current must circulate round the ball, without going deeper into the question of this current. Lafay had already made similar measurements over ten years before in Paris.

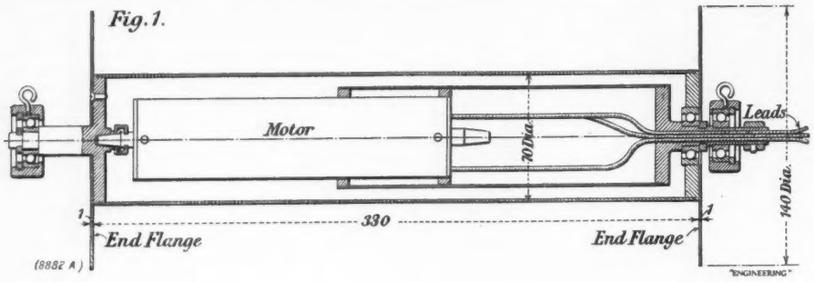
The Göttingen laboratory had repeated Lafay's experiments for purely theoretical reasons, at the end of April, 1923, on the suggestion of Herr Ackerat, one of their departmental heads, since their plant was particularly suited for such a course of experiments. The laboratory staff had no idea of putting the effect to practical use. They only refrained at first from publishing their results as they intended to study the effect later with better means. When I heard of the Göttingen experiments, I realised the danger that someone might anticipate me by lodging an application for a patent, especially as I had had research work carried out in Göttingen on other lines, but on the subject of sails. I therefore applied immediately for a patent. I made the first experiments on water, on the Wannsee, near Berlin, with a little model ship which carried a paper cylinder, driven by clockwork, and 15 cm. in diameter by 40 cm. high. After these experiments, I informed the Göttingen authorities of the matter, and it was agreed that further research work on rotors, especially as far as their use as sails was concerned, should be carried on at the expense of our company. I would state here that the first repetition of Lafay's experiments dealing with the Magnus effect was undertaken independently by us; that the adaptation of the principle to the sailing ship was my idea only, and that it was developed on my account and at the expense of my company. As I heard later from Göttingen, the principle had already been proved to give much higher values than had been found by Lafay, even before we started the experiments from a practical point of view. I might mention that my ideas were met at the outset with surprise on the part of those gentlemen who had already been occupied with quantitative experiments on the Magnus effect. It must not be forgotten that, so far, no even approximate estimate was possible of the force required to rotate the towers, of the weight of the high towers themselves, of the vibrations induced by the rotation of these great bodies, and the effect that this would have on the ship, of the behaviour of the towers when not turning in gales, and so forth.

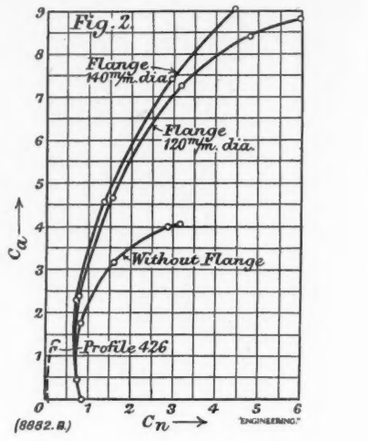
The proposed large metal cylinders, which are arranged on the ship to turn freely, constituted indeed the most difficult scheme of the type attempted. Considerable doubt was expressed concerning the feasibility of the idea, particularly by naval architects. Even my collaborators were sceptical up to the last weeks, as to the results of the experiments, and warned me not to over-estimate the value of the partial results which we obtained in experiments at the shipyard. Aerodynamical experts also considered the building of a full-scale plant solely on the results of experiments with such relatively small models as quite unjustified.

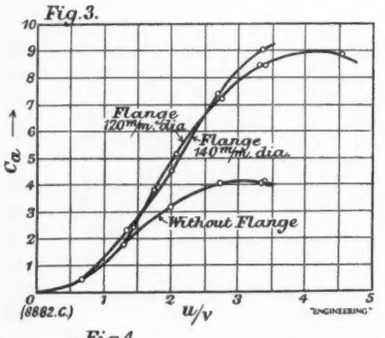
Fig. 1, page 118, shows, in section, one of the experimental rotating cylinders, which is constructed in one with its motor. It is made of brass tubing and is 35 cm. long by 7 cm. diameter. The armature of the motor is attached to the cylinder, and is carried in a ball bearing in the stator, which is suspended so that it may be turned about its axis in order that the torque necessary to cause rotation may be measured. Current is led to the motor by three wires passing through the hollow spindle. Free movement is assured by mercury contacts. At the ends of the cylinder will be noticed two flanges. Professor Prandtl had suggested these at Göttingen, to keep the vortex as near as possible to its theoretical value, whilst I had independently

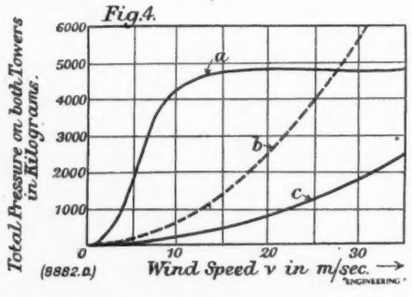
* Abstract of a paper read before a meeting of the Schiffbautechischen Gesellschaft on November 21, 1924.

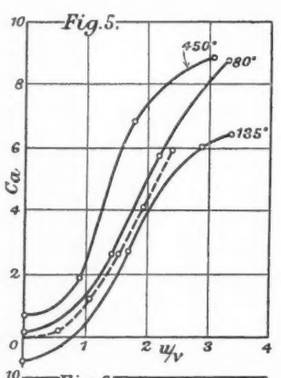
included them in my patent for the practical design of the rotor ship, to reduce loss of effect at the ends of the cylinder, without knowing of this previous use of them. Fig. 2 shows certain of the results. In the curves shown here the scale of values for propulsive power and for resistance are taken as equal. The $c_a$ "lift coefficient" values are relative to the banking-up pressure and the superficial area of the cylinder. For comparative purposes, the curve of a very good aeroplane wing of the usual type, is included in the diagram, and is indicated by the dotted curve. That of a sail would be so poor in comparison that it would not even reach the value 1. One can see immediately, from this curve, the remarkable contrast in absolute value of propulsive effort and resistance value between the usual wing section and the rotor. The fully developed curves are those of cylinders with flanges of different diameters, as compared with a cylinder without end flanges. The great effect of the end flanges is visible

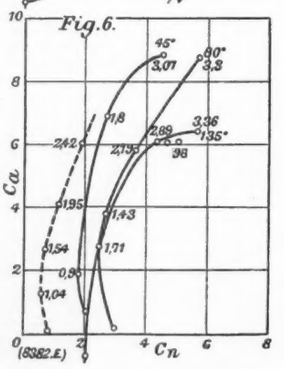


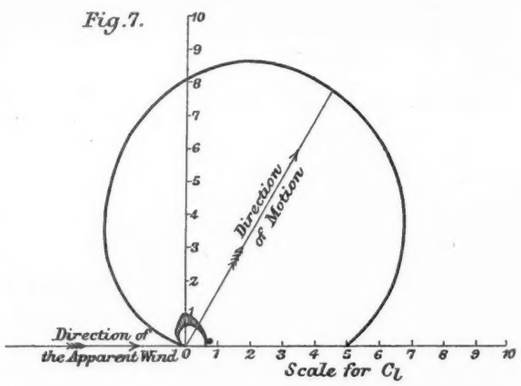



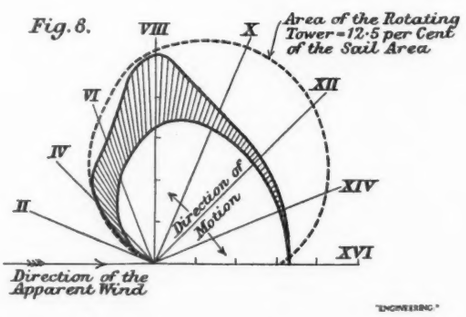




here, and explains why Lafay, who had not thought of using them, only obtained propulsive effort values up to about 2. On comparing the curves, it can be easily seen that the induced resistance is greatly reduced by means of the end flanges. The curves in Fig. 3 show the influence which the relationship between speed of rotation and wind speed has on the propulsive effect. When these speeds are equal, this is already greater than with an ordinary sail, the value of which is about 0·8. When the peripheral speed of the cylinder is 3·5 times the wind speed, the propulsive effort has already reached a value of more than ten times that of a sail. Here also the influence of the end flanges is plainly apparent.

The curve, Fig. 4, shows clearly the nature of the forces involved with the cylinder rotating and at rest, compared with the resistance of the usual rigging of a ship. Curve *a* shows the pressures on both towers, with a peripheral speed of 24 m. per second. Curve *b* shows the wind resistance of the rigging, *c* that of the cylinder when not rotating. It is plainly shown how the effect on the rotating cylinder ceases to increase beyond a wind speed of about 12 m. per second. This is a matter of the greatest practical importance. No more force is taken from the highest winds than is appropriate to the peripheral speed. This advantage cannot be too strongly emphasised from the point of view of sailing. The mariner will always be able to derive propulsive power from the strongest gales, provided, of course, that he is not prevented by nautical reasons, such as too high a sea. Should the rotor for any reason stop rotating, the resistance of the cylinder is, as the curve shows, very much less than that of the bare rigging. It is possible, at will, therefore, to obtain any of the conditions lying between curves *a* and *b*.

The graphs, Figs. 5 and 6, show results obtained with a scale model of the Buckau with two rotating cylinders. This model was made to determine the effect produced by both cylinders and by the hull. You see here the propulsive forces $c_a$ plotted in relationship to the $\frac{u}{v}$ ratio, where $u$ denotes the surface speed of the tower and $v$ that of the wind. The different curves show very distinctly the changing effect of the hull and of the cylinders at different angles to the wind. In the diagram Fig. 6 is shown propulsive force in relation to resistance.

Fig. 7 shows the values of the model brigantine Buckau, plotted on the same scale as those of the model of the same ship with both towers revolving in the right direction for forward motion. The enormous advantage of the rotating cylinders, compared with sails, is once more illustrated. Whilst values were attained with the brigantine in the neighbourhood of 0·8, those given by the model with rotating cylinders amount to between 8 and 10, according to the diameter of the end flanges. More than ten times the power derived from sails is given by the rotating cylinder, as has been proved by such tests as have been carried out on the Buckau. From Fig. 7 may be taken the relationship of the forces brought into play with the course of the ship at different angles to the wind.

In Fig. 8 the curves of the brigantine and the rotor model are plotted so that the relationship of the forces may be studied when the projected area of the cylinder is one-eighth that of the sails. The lower curve shows the values with unfavourable trim of sails, the upper one those with an ideally favourable setting. The actual curve should run half-way between the two. Fig. 9 shows the comparison between the performance of an exceptionally good gaff mainsail and of a rotating cylinder of the same projected area. The curve is not carried further, as the experiments were not completed.

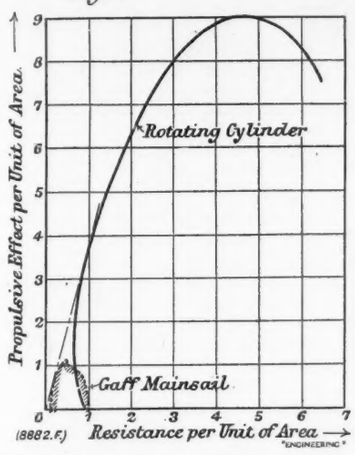
An experiment was also conducted with a rotating cylinder with a fluted surface, 800 mm. high, and with end flanges 280 mm. diameter. This cylinder was first tested with a smooth surface. The results agreed, on the whole, with the earlier ones. After flutes of a width of 10 mm. and 3·5 mm. deep had been cut in the cylinder, the experiments were repeated. The propulsive values were, on the whole, good. The resistance with the cylinder not rotating, however, was rather large compared with the smooth cylinder, and it is noteworthy that no drop in resistance was observed at the highest speeds with high Reynolds numbers. The resistance of the cylinder with high Reynolds numbers is 0·7 instead of about 0·3. On this account we at once gave up the idea of using a grooved cylinder for our purposes.

Before I now go on to the practical experiments with, and the construction of the Buckau, I should like to deal with the theory of the Magnus effect. It is not

yet possible to describe exactly the action of the wind currents. Professor Prandtl's "boundary layer" theory, however, provides a plausible explanation of the phenomenon. Professor Prandtl asserted 20 years ago that the frictional effect of a fluid is restricted mainly to a proportionately thin layer near the body, *i.e.*, to the so-called "boundary layer," which in most cases prevents the formation of ideal stream-lines according to the "potential" theory. Fig. 10 is an illustration of the true potential current. Fig. 11 shows the rotary current which can be imagined as imposed upon the potential current. This would resolve itself into a potential current with some rotary movement (Fig. 12). All these matters have been frequently studied and fully described.

Fig. 13 shows diagrammatically what happens when a true potential current meets a rotary current of very

*Fig. 9.*




great velocity. The astonishing effect of this condition of current round a rotating cylinder is the sudden increase of pressure. Under the full influence of the "boundary layer," such a rise in pressure would not be possible. The rise in pressure would have to result much more gradually. With a suitable proportion of $\frac{u}{v}$, the peripheral speed of the rotor must be equal to or greater than that of the molecules of air on almost the whole of the low pressure side. It must not be concluded that little or no skin-friction occurs, particularly at the point of lowest pressure, where the speed of the rotating wall and of the air molecules are approximately equal, or that therefore an inert "boundary layer" either does not occur at all in this zone, or only very slightly. This explains the possibility of a sudden increase in pressure without a breaking up of the streamlines. We know that with the cylinder motionless, the "boundary layer" breaks away more or less symmetrically to the direction of the current, shortly after crossing the zone of lowest pressure. With rotation, this breaking away is markedly unsymmetrical resulting in asymmetry of the stream, and hence in a propulsive force. The higher the speed of rotation, the more the point of the break away is shifted. After close study of the phenomena, the view is suggested that the air becomes diverted into a rotary current in a wide area round the cylinder.

Fig. 13 shows diagrammatically to what extent the streamlines approaching the high pressure side are drawn across to the side of the low pressure. It will be clear, even to the non-technical mind, that the air prefers to move towards the low pressure side, rather than to the high-pressure side, when the cylinder wall is constantly rotating against it with many times its speed, and builds up a rise in pressure as high as the speed of the wind will permit.

Fig. 14 shows the proportion of pressure to suction on a non-rotating cylinder, as has been already described by Lafay and others. The area denoting pressure is marked with plus signs, that of suction with minus signs. Fig. 15 shows the distribution of pressure when the cylinder rotates, with a peripheral speed of three to four times that of the wind. In this instance, I might have been tempted to give you a nice illustration showing an area of low pressure on one side and a proportionate area of enormously high pressure on the other. In my various papers on the current operated rudder, I have always laid emphasis on the fact that in all applications of the laws concerning currents, the low pressure side is the most important and that when it is desired to utilise to the fullest extent the forces latent in currents, the side of low pressure must be considered first and care taken to make use of the

*Fig. 10.*

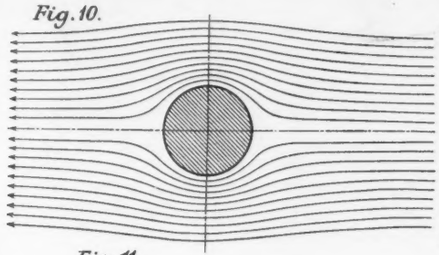


*Fig. 12.*

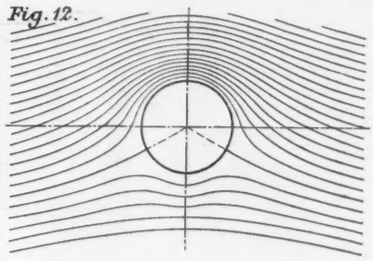


*Fig. 11.*

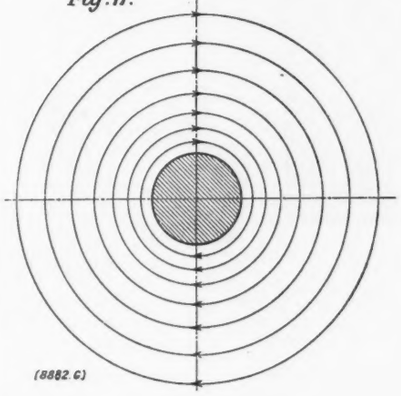



*Fig. 13.*

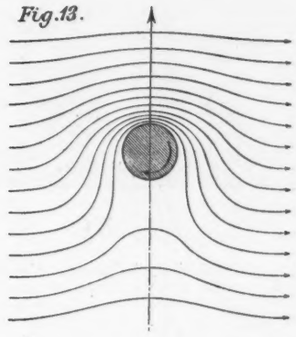


*Fig. 14.*

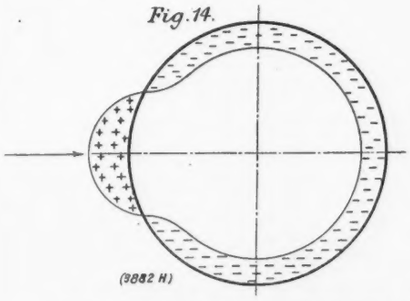
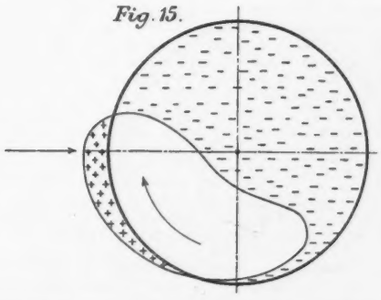



*Fig. 15.*



pressure. This fact explains the ability of the Buckau, in spite of the unfavourable influence of the hull, to sail within three points (*i.e.*, about 30 deg.) of the wind.

For full scale experiments, the auxiliary three-masted topsail schooner Buckau was chartered by Messrs. Krupp from the Hanseatic Motor Ship Company of Hamburg. Two fixed shafts without stays were built into the hull, of 1·5 m. diameter at the main deck and 13 m. high above deck. Surrounding the shafts were two cylinders arranged to turn on two bearings, and built of steel sheets 1 mm. thick, stiffened crosswise and vertically. The cylinders have a diameter of 2·8 m., and were first built 15·6 m. high. This represented an area equal to about one-tenth of that of the old sail plan. An increase in height to 18·5 m. was seen to be necessary after the first few long trips. The upper bearing is designed to take side thrust, and at the same time to carry the weight of the cylinder. The lower bearing deals with only small pressures. In this first installation, ball bearings were used throughout.

The cylinders are rotated through gearing, having a ratio of 6 to 1, and arranged at the upper bearing. Vertical driving shafts lead down from the gearing to two reversible direct current shunt-wound motors of 11 kw., 220 volts, 750 revolutions per minute, placed inside the supporting shafts at deck level. Current is obtained from a 45 horse-power two-cylinder Germania Diesel engine.

The following is a brief account of the results which have been achieved. The stability of the ship has been greatly increased by the conversion. Whilst the old rigging weighed 35 tons and had a total height of 25 metres, both pivots complete with cylinders weigh about 7 tons and are 15·6 metres high. Since the propulsive effort is dependent on the relationship between peripheral speed and wind speed, and since the peripheral speed can be kept constant and never rises above a fixed maximum, the wind pressure on the rotating cylinders can also rise only to a certain height, even if the wind speed itself increases enormously. Hence the rotors can continue to function in very high winds. For this reason also, very strong squalls have but slight effect on the ship, and pass almost unnoticed. When, for example, the rotor is turning at a peripheral speed of 24 metres per second, in a wind of 8 metres per second, and a squall of 8 to 12 metres per second passes, the ratio of $\frac{u}{v}$, which at first was 3, is automatically reduced to 2. In spite of the fact that the wind itself has grown much stronger, its effect on the rotor is thus automatically relatively reduced, so that practically no increase in pressure is noticeable. The phenomenon, which could be anticipated from calculations based on the experiments, was amply confirmed by the first trial trips. In this particular lies a great advantage as compared with the old sailing ships. One can control absolutely the wind pressure on the ship, by rotating the cylinders at a suitable speed, and almost instantaneously. It is thus unnecessary, as was the case with the old sailing ship, to start shortening sail long before the approach of a storm. Moreover, as already mentioned, the resistance of the stationary rotor is low, compared with that of the old rigging with sails stowed.

In the course of the research with cylindrical bodies, it was found that the resistance value does not only depend on the form and position of the moving body,

# 2½-INCH SCREW-CUTTING AND TURRET LATHES.

CONSTRUCTED BY THE EXE ENGINEERING COMPANY, LIMITED, EXETER.

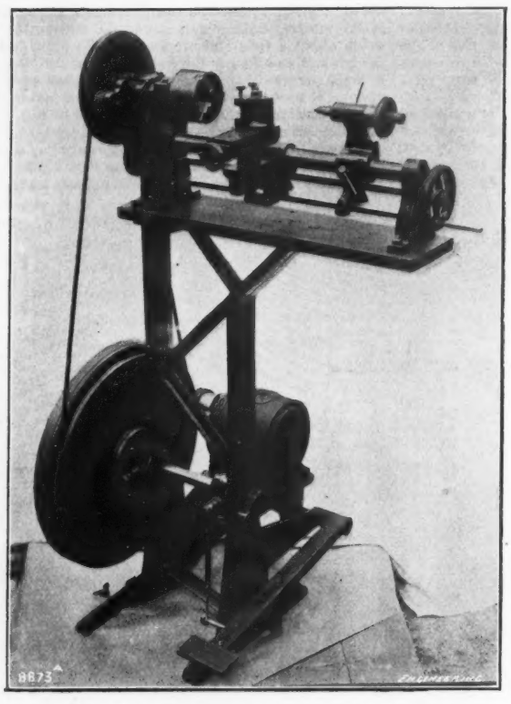


FIG. 1.

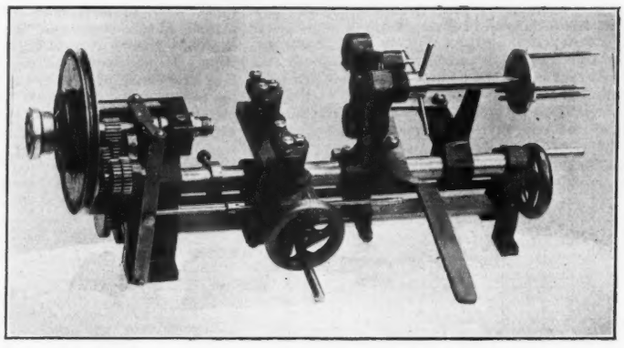
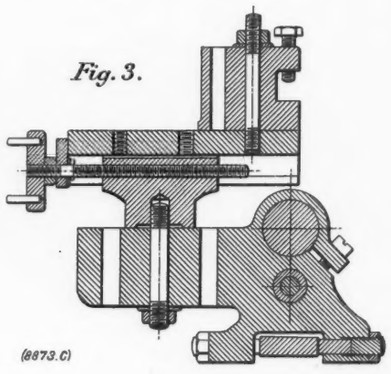
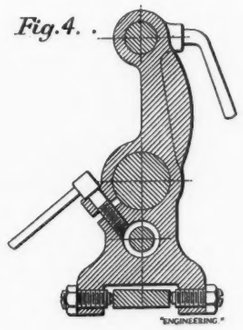


FIG. 2.




but that a geometrical similarity must also exist in the stream-line form. This similarity occurs only under quite definite conditions which have been determined by Reynolds. It was established that the resistance of cylindrical bodies of a certain diameter does not increase with increasing wind velocity per unit of superficial area, but that according to the given conditions, there is a sudden drop in the curve of resistances. According to the Göttingen figures, a resistance value of about 0·3 is to be reckoned on with our 3-metre diameter cylinder at the wind speeds with which we have to deal, since the Reynolds numbers concerned lie beyond the critical value. It can be calculated that the surfaces which must remain standing in a storm, *i.e.*, masts, shrouds, yards, standing and running rigging, amount to 12 to 15 per cent. of the total area, from which a resistance value of 1 to 1·2 is to be reckoned on, since these bodies have a very unfavourable form from the point of view of resistance. As the curve shows, the total resistance of the cylinders is much lower than that of the old rigging with furled sails.

Irregular forces, brought into play by the rolling and pitching of the ship, were found after careful calculation to be extremely low and never to reach a value of any importance. The periodicity which might be set up in the transmission by lack of balance of the cylinder, was found by calculation never to reach a dangerous degree. The actual trials of the ship have also proved that any fears on this account are groundless. Damage of the cylinders by seas is scarcely to be apprehended. Nevertheless, a thicker gauge of plate was used for the lower part of the rotors.

Control at sea is extraordinarily simple. Only one man is needed to manage the electric controls of the rotors. Weather or lee helm can be counteracted in the simplest way by merely altering the relative speeds of the rotors. The ship can be helped in going about by reversing the direction of rotation of the forward or after cylinder. The trials have shown that the ship is not brought up during this manœuvre, but carried on through the wind's eye like a yacht. By reversing both cylinders, it is possible to move full speed astern. Due to the duplicated transmission, the driving gear is extremely reliable. Getting under way is also rapidly carried out. The operation corresponding with setting or stowing sail does not take any length of time, but can be carried out in a few seconds. It is no longer necessary to keep a careful eye on the barometer and weather signs, so as to prepare ahead for changes of weather. The mariner is able instantaneously to adjust his vessel to any sudden change.

Even considerable changes in the direction of the wind need not be taken into account, as the rotors need no modification to meet them. It is only necessary to reverse the rotors when the wind comes on the other side of the ship. Apart from slight variations in their speed of rotation, to meet considerable changes of wind speed, the rotors require practically no attention. When sailing close-hauled, the proportion of $\frac{u}{v}$ is somewhat reduced, and it is increased when running free.

As has been frequently mentioned, the trials have proved that all expectations which were based on the Göttingen experiments have been entirely fulfilled. The efficiency of the system has been satisfactorily proved. I have always been of the opinion that the new system would never replace the modern steam or motor-ship, but that it would have a definite value as an auxiliary to the highly developed engine for ship propulsion, by utilising to the full the available wind power, and it would thus effect great economies in fuel consumption.

## 2½-IN. CENTRE SCREW-CUTTING AND TURRET LATHES.

THE man with a small workshop and the amateur mechanic requiring a lathe capable of being operated by a treadle have been well catered for in the past, but the general developments which have taken place in the design of machine tools have not been without important influence on this branch of light engineering. It is probable that the present widespread interest in wireless work has added very considerably to the number of those making a demand for such tools, and those who are in this way newcomers to the interest of mechanics are presented with a range and variety of tools of which the model-maker of years ago had no conception. The lathes with which we are concerned in this article illustrate this well, since quite apart from the excellence of design of the 2½-in. centre screw-cutting lathe which is shown in Fig. 1 above, a turret lathe forming a modification of the same design has been introduced, and is shown in Fig. 2. This turret lathe, which like the screw-cutting lathe may if desired be operated by a foot treadle, is probably likely to be of more value to the small professional worker than to the amateur, and should be of particular interest to the very many small firms which are now engaged in the manufacture of wireless parts or models.

The lathes, which are constructed by the Exe Engineering Company, Limited, of Exeter, are similar as far as concerns the bed, headstock, saddle, and some other main parts, and we may devote our main description to the screw-cutting lathe, referring afterwards to the special features of the turret lathe. The screw-cutting lathe is of 2½-in. centres, and has a swing of 4¼ in. over the saddle. It can deal with work 12 in. long between centres. The bed, as will be seen from Fig. 1, and as is also well shown in the cross sections of the saddle and tailstock in Figs. 3 and 4, consists of a solid round steel bar with a rectangular bar mounted below it. As will be evident this gives a very rigid construction. An important point is that as the work is situated at about the same distance from the centre of the circular bed as is the guide bar, any error in this latter is not multiplied at the work, as is the case when a slot in the circular bed itself is used as the guide. Both bars forming the bed are ground to fine limits, and the saddle and tailstock are provided with adjustments for taking up wear on the bars as is shown in Figs. 3 and 4.

The headstock is of quite novel design in that the main pulley is carried outside the outer bearing. This arrangement has been adopted in order that a large pulley may be used and back-gear eliminated. The pulley has three cone sizes, 7¾ in., 4 in. and 2 in. diam., and with the large pulley in use the same speed reduction is obtained that a back gear would give and the friction of gears is avoided. It is claimed that the arrangement gives a steadier drive than a back gear, and that the flywheel effect of the pulley assists treadling. Driven by treadle, the lathe has turned 1 in. steel down to ⅝ in. in one self-acting cut of 110 per inch, and can deal with cast-iron parts as large as the lathe will swing without chatter. The mandrel, which is carried in adjustable bronze bearings, has a ⅜-in. clearance hole through it. The change-wheels are machine cut from the solid

and allow of all usual standard pitches and many odd ones to be cut. The saddle traverses the whole length of the bed. The lead-screw is used for this, being operated by the handwheel at the right-hand end of the lathe. The slide rest, which has a V-bearing adjustable for wear, may be swivelled to any angle. It can be bolted to three positions on the saddle so that while work of large size may be turned between centres it is also possible to get close up to small work. The slide traverse is 2½ in. A screw-cutting clutch is fitted which automatically picks up all threads correctly in pitch. This feature is of considerable value for amateurs or comparatively unskilled workers. The tailstock, of which a section is given in Fig. 4, is provided either with a screw feed, as shown in Fig. 1, or with a lever feed. It can be set over for taper turning. The girder construction of the lathe makes it very rigid, while it is actually, for its class, a fairly heavy tool, the bench lathe alone weighing 52 lb., and the complete foot lathe 185 lb. A self-contained electric drive, as shown in Fig. 1, forms part of the equipment when desired.

The turret lathe, which is illustrated in Fig. 2, is in its bed, headstock, pulley, bearings, change-wheels, clutch and saddle similar to the centre lathe. The mandrel, however, has a ½ in. hole through it instead of ⅜ in., and has larger nose. As will be seen, in the turret lathe the slide is extra long and is provided with two tool-posts for front and rear cutting. The cross-feed handwheel has a micrometer index. The clutch, which as in the centre lathe picks up all threads, including odd and fractional pitches, correctly in pitch every time, can be set to declutch at any point by means of a stop, so that threads may be cut up to a shoulder. The turret has a stroke of 4 in. and has three ⅝-in. holes to carry tools, each being provided with a separate adjustable stop. The weight of the turret bench lathe is 61 lbs.

## THREE-WIRE DIRECT-CURRENT DISTRIBUTION NETWORKS.

*Three-Wire Direct-Current Distribution Networks: Some Comparison in Costs and Operation.**

By HERBERT WILLOTT TAYLOR, Associate Member.

(*Concluded from page* 89.)

*Three-core cables.*—A network in which three-core cables are used for the distributors has not the same attractive features as those outlined in the system described above. The earthing of the neutral through a light fuse is unsuitable with such cables. The reason for this is that in a three-core cable, whilst it is possible to have a fault to earth on one live core without the others being affected, the time usually necessary for the trouble to spread and cause a short-circuit between cores is too brief for any material advantage to be gained by its adoption. It is thus necessary for the neutral to have some form of permanent earth connection and for suitable protection to be provided to operate on a fault to earth or between cores.

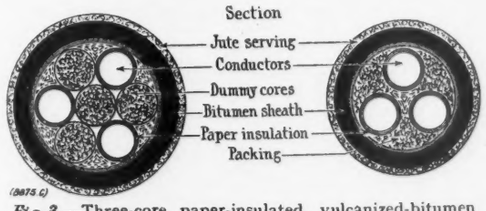



*Fig. 3.*—Three-core, paper-insulated, vulcanized-bitumen cable with dummy cores, and its diameter compared with that of a standard 3-core cable.

The protection of a distribution system is necessarily a compromise between conflicting conditions. On account of their low cost and simplicity, fuses installed in network boxes or pillars at convenient junctions of distributors are relied upon to isolate a faulty section. The inherent weakness of the fuse is, however, plainly demonstrated on heavy faults, when, due to its lack of discrimination, large healthy areas are cut off together with the bad ones. For this reason fusing points should not be multiplied unnecessarily. Besides being more expensive, the introduction of fuse boxes in the place of the link boxes decreases the reliability of the network.

As it is not necessary to cut any of the cores when a service connection is being made, the supply need not, in cases of urgent necessity be interrupted during such time; but wherever possible it is better to make the distributor dead, as this allows the jointer to work in absolute safety and better workmanship is thereby obtained.

Trouble has recently been experienced on three-core distributors due to the straining of the cores when they are wedged apart to allow service connections to be made. When such connections are numerous, this strain may become serious. To overcome this difficulty, Messrs. Callender's Cable and Construction Company, Limited, have produced a three-core cable the section of which is shown in Fig. 3. In the centre is a hemp core, around which are placed the three conductors which, in turn, are separated from one another by means of three or more hemp cores. When a joint is being made these hemp cores are all cut away, thus leaving the conductors sufficiently spaced to allow the soldered connections to be effected without any straining whatever.

*Triple-concentric Cables.*—The triple-concentric cable has such obvious disadvantages for low-tension direct-current distribution systems that it is remarkable that any undertaking ever adopted it for the smaller sizes of cables. It has most of the disadvantages of the three-core cable enumerated above, as well as additional ones, against which it can only show a slight superiority in a reduction of cost and diameter. In addition, there are disadvantages arising out of the method of jointing.

The inner and middle cores of a triple-concentric cable are usually connected to the positive and negative poles, the smaller outer core forming the neutral. This arrangement is maintained throughout the system so that a joint cannot unwittingly be made with the wrong polarity.

With lead-covered armoured cables laid direct there would, however, seem to be something in favour of the outer core being made positive, the middle neutral, and the inner negative. In this case the lead sheathing, which is bonded throughout the network, provides a direct metallic connection between a faulty positive core and the station earth plate. Should a cable so connected be damaged, perhaps by the inadvertent blow of a pick, causing the lead sheathing to be pierced and come into contact with the live outer core, a fault is immediately apparent and can be repaired at once and at a low cost, which cost can be recovered from the authority responsible for the damage.

Supposing, however, that the outer core had formed the neutral, the man with the pick would not be aware of any trouble and no indication would be perceived at the station. After a lapse of perhaps months, when all recollections and evidences of the roadway having been disturbed have gone, a fault would be found to have developed due to water penetrating through the punctured sheathing. The fault is not then so easily traced, and perhaps large expenditure is incurred which would not have been necessary had the circumstances been as in the case previously described. Moreover, due to lack of concrete evidence, blame cannot be fixed on any other authority, which means that the whole cost of the repair has to be borne by the supply undertaking. Making the outer core positive would also tend to prevent moisture from penetrating to the inner portions of the cable.

*Method of Laying.*—Drawing cables into ducts offers no considerable advantage for distribution work, so that the choice is limited to the direct and solid methods. In connection with these there are no new points that did not arise when reviewing their application to feeders. There is, however, one weakness in the solid system that is not of great moment on a feeder, but its presence is very much more likely to cause trouble on a distributor on which there will usually be numerous joint boxes. However well a joint is packed up below, pressure from above will cause it to sink slightly when the ground is filled in. The subsidence of the box is liable to crack the bitumen at the joint of the box and troughing and thus allow water to enter and ultimately cause a breakdown.

Distributor cables, even more than feeder cables should, wherever possible, be laid under the pavement. The advantages gained by so doing are many, the most apparent being: (1) All service cables are shorter and therefore cheaper. (2) Owing to the absence of heavy traffic over them they can be laid much less deeply, depths of 12 in. to 18 in. being as a rule sufficient, resulting in less expensive trench work. (3) The ground around the cable is usually drier. (4) Repairs are cheaper. (5) More room is obtained, as gas, water and sewage mains are usually all in the roadway.

TABLE V.—*Cost of 0·2 sq. in. × 0·1 sq. in. × 0·2 sq. in. distributors per 100 yards.*

| Type of Ground Surface. | Lead-Covered, Steel-Tape-Armoured, Laid Direct. | | | Vulcanised Bitumen, Laid Solid. | | |
|---|---|---|---|---|---|---|
| | Three Single Cables. | Three-Core Cable. | Triple-Concentric Cable. | Three Single Cables. | Three-Core Cable. | Triple-Concentric Cable. |
| | £ | £ | £ | £ | £ | £ |
| Setts on a 6-in. concrete foundation | 213 | 204 | 201 | 260 | 238 | 238 |
| Waterbound macadam | 128 | 120 | 117 | 170 | 149 | 148 |
| Flagged pavement | 120 | 111 | 108 | 161 | 140 | 139 |

*Costs of Distributors.*—Table V shows the comparative costs of laying distributors under different types of ground surface, while Table VI gives the approximate depths of track that have been allowed for in each case.

TABLE VI.—*Depth of Track for Distributors.*

| Type of Ground Surface. | Cables Laid Direct. | Cables Laid Solid. |
|---|---|---|
| Setts on a 6-in. concrete foundation | 2 ft. 0 in. | 2 ft. 6 in.–3 ft. 0 in. |
| Waterbound macadam | 2 ft. 0 in. | 2 ft. 0 in. |
| Flagged pavement | 1 ft. 3 in. | 1 ft. 3 in. |

It will be seen from these figures that there is very little difference in the costs of three-core and triple-concentric distributors, whatever difference there is being due to the slightly higher cost of the three-core cable. There is thus no financial justification for the preference of the triple-concentric cable, with its inherent disadvantages.

The distributor made up of three single-core cables involves rather more expenditure than either of the other two, though this extra cost detracts very little from its manifold advantages, and, for the reasons already explained, the additional outlay is fully justified.

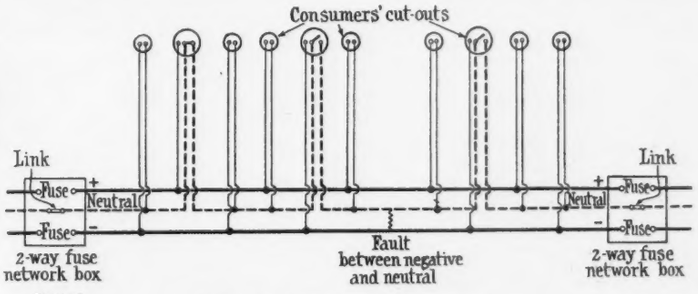



*Fig. 4.* "Looped-neutral" services.

As previously stated, the chief factor in determining the size of a distributor is the maximum voltage-drop allowable so as to comply with the Electricity Commissioners' regulations of ± 4 per cent. variation in voltage. It is not, therefore, generally possible to take much advantage of the higher permissible current-carrying capacity of single-core cables, but it is well to remember that this good quality is a useful stand-by in cases of emergency when overloads may be temporarily thrown on to a particular distributor due to a breakdown at some other point of the network.

*Looped Neutral Services.*—While dealing with the subject of distributors it might not be out of place to put forward a suggestion which the author considers will greatly facilitate the location of faults on vulcanised-bitumen triple-concentric distributors up to about 0·2 sq. in. cross-section, and help to preserve the continuity of supply under fault conditions.

As faults on modern cables are usually due to external causes, the majority of faults on a triple-concentric distributor are between the middle and outer cores, *i.e.*, between negative and neutral. This being the case, it is only necessary to cut the neutral core to enable a test to be taken that will show in which direction the fault lies.

If the neutral of the distributor is looped in at several

* Abstract of paper read before the Institution of Electrical Engineers, on January 8, 1925.

of the services along its length, a convenient method of breaking its continuity is provided without any excavating being necessary, thereby effecting a considerable saving in time and money (see Fig. 4). The fault having been traced to a position between two consumers in whose premises the neutral is disconnected, the supply can now be restored to all the consumers with the exception of those tapped off the faulty length. If the fault be between all three cores the positive and negative cores should be bridged at the network box and only one fuse replaced.

Where it is decided to adopt this system on an existing distributor that is not already supplying all the possible consumers, it can be installed whenever a suitable service is being laid, so that no scrapping of existing material is necessary. The increased cost of such services depends upon their length and the size of the distributor, and amounts to from 25*s.* to 2*l.* for short services. The saving in the event of *one* fault may cover the extra cost of many looped services.

*Services.*—The type of cable and the method employed in laying the distributors is usually adapted to the services tapped from them. This preserves the symmetry of the network and generally simplifies the connections in the service joint boxes. For this reason, before any particular system for the distributors is decided upon the question of services should be considered.

As in the case of feeders and distributors, single-core lead-covered armoured cables possess the most advantages for services. One advantage of this type of cable is that the risk of fire is greatly reduced. A fault on such a cable inside a consumer's premises has only to blow the light station earth fuse to clear itself. With a concentric or twin cable, however, the heavy street fuses on the distributors have to blow before the fault is cleared, and in the meantime a fire may have been caused. For this reason concentric or twin service cables should be laid with more care inside the consumer's premises, anything inflammable being strictly avoided.

The service joints on single-core cables are simple to make, resulting in an increased reliability which more than counterbalances the necessity of having two or three service boxes for direct-laid armoured cables, in place of the single one used for multicore cables. The time taken by the jointer to fix the additional joint-box does not in practice affect the cost of the service, as a standard time, based on average circumstances, is usually allowed for the completion of ordinary services.

The armoured service is so much easier to lay, under all conditions, than is the vulcanized-bitumen solid-laid service that some undertakings actually connect armoured service cables to old vulcanized-bitumen distributors. This fact eloquently supports the armoured cable's claim to priority.

In the author's experience the weakest point in a vulcanized-bitumen service laid solid is where the cable passes through the outer wall of the building; here it may take a sharp upward bend to the cut-outs. If the wall is thick the difficulty of making a sound job of the troughing may contribute towards the frequent breakdowns that occur at this point on old services, but, as bitumen is readily attacked by alkaline salts, the lime in the wall is probably the cause of most of the trouble. At all such points the cable should be drawn through small earthenware pipes with suitable bends and filled with bitumen.

Where the service cable has to cross a hard road or any other ground that is expensive to excavate and reinstate, it is advisable to draw a lead-covered cable through small earthenware conduits, in order to lower the cost of repairing faults that might occur on that section. These conduits should be short—not more than 2 ft. in length—to enable the numerous pipes, &c., that are often encountered when crossing a road to be more easily avoided.

For large consumers who cannot afford to be shut down for any length of time in the case of a fault, it is very often expedient to loop a three-core or triple-concentric distributor into their premises, so that they may always be given a supply, even though a fault may exist on either of the two sections of the distributor supplying them.

This is not necessary on single-core lead-covered systems, due to the freedom from interruptions of supply experienced on such systems.

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MAGNETIC DECLINATION IN 1925.—The magnetic declination continued to decrease, *i.e.*, became less westerly, during the past year, as it had been doing since about 1810, at the average rate of about 0·15 deg. At present the compass needle points in Europe to the west of the true north. This declination amounts in Rome and Berlin to about 7 deg.; in Zürich and along the west coast of Denmark to 9 deg.; in Brussels and Toulouse to 11·5 deg.; in Paris to 12 deg.; in London to nearly 14 deg.; along the west coast of Wales to 16 deg.; and the north-west of Scotland to 18 deg.

## EAST AFRICAN TRADE.

AT the present time when large numbers of foreign traders in all branches of commercial activity are adopting the extended payment system of settling for goods purchased, it is evident that the firm working on a quick-return basis will be severely handicapped in competing for orders against business houses giving longer credit, and will, in general, be supplanted by the more accommodating supplier. This is the state of affairs which exists, particularly in Canada and East Africa, to the detriment of the British merchant. For example, Canadian importers usually seek credit of 30, 60, or 90 days, which is freely extended to them by United States dealers, and it is consequently difficult for British manufacturers to secure "cash against documents" or "cash before shipment" as a few request. Some idea of the extent of this handicap in such British territories as Uganda, Tanganyika, Kenya Colony and Zanzibar may be obtained from particulars which are included in a Report on the trade and commerce of East Africa for the year ending September 30, 1924, compiled for the Department of Overseas Trade by Colonel W. H. Franklin, H.M. Trade Commissioner in East Africa.

With regard to imports into these districts the United Kingdom at present virtually commands the market in cement, supplying approximately 72 per cent. of the annual demand of 11,500 tons, but increasing competition has been felt of late. Again, we almost maintained in 1923 our normal share in the iron and steel manufactures taken into those countries, supplying goods to the value of 427,076*l.*, but this was not so well maintained in 1924, when continental competition in enamelled hollowware, wire, wire nails, screws and rivets, sometimes under-cut our prices by as much as 30 per cent. During the first half of 1924 our part of this trade amounted to only 47,276*l.* In cutlery, hardware, and instruments this country has lost a lot of ground to Germany, who in pre-war days enjoyed a fairly good share of these imports. For the first half of 1924 we supplied material to the value of 32,670*l.* The Report stresses the great attraction of cheapness of original cost, not only to the native buyer but also to a large part of the consuming market formed by immigrant races. As a result of conditions in Germany that country's manufactures are much cheaper than British articles, and this is an important factor in her increasing sales. The non-ferrous manufactures trade, on the other hand, is largely in the hands of the small Indian trader as the ultimate distributor, and he is mainly responsible for the continued importance of India in the market in brass and allied goods, though Germany is increasing its share of supplies in this department also. There is a small demand for tin sheets, but virtually no call for brass or copper sheets.

The position of the United Kingdom with regard to machinery and electrical goods and apparatus is strong, supplies to the value of 155,928*l.* being taken from us during the first half of 1924. In Kenya and Tanganyika particularly there has recently been a large increase in these markets, amounting to some 80 per cent. This is due to increased areas of European settlements coming into the bearing stage, and also to some developments in the way of demand for ploughs by native producers. The remarkable increase in the import of bicycles, from some 2,000 in 1923 to about five times this number in 1924, into Kenya and Uganda is mainly a reflex of the prosperity of the native grower of cotton in Uganda. In the latter Protectorate he wants, and can generally afford, a quality article, but there are other parts of the dependencies where his purchasing power is obtained from low value crops and the cheap German machine thus often finds a ready sale, priced at 40 per cent. below the British article. In consequence of the better financial position of European and native settlers and the possibilities of profitably opening up areas further removed from existing transport facilities, the number of motor-cars on the roads has largely increased also, and this has been amply reflected in increased import returns, especially during the first six months of 1924, when 424 were taken. American makes of cars largely predominate, however.

Among the exports of these dependencies that of mineral mica is increasing rapidly and deservedly so, for the quality is first-class. Gold was exported from Tanganyika during 1923 to the amount of over 1,325 oz., and active prospecting is meantime in progress. The Sekenke mine has now been put in order and is expected to yield a substantial supply of this metal.

Any estimate of the state of these countries would be incomplete without reference to the railway harbour and shipping position. The Uganda Railway, during 1924, earned a gross profit of 415,351*l.*, out of a revenue totalling 1,237,736*l.* This result has stimulated development and a regular service to Eldoret on the new Uasin-Gishu line will commence shortly. The revenue of the Tanganyika Railways for the year 1923–24 was lower than the working expenditure, but it was expected that these would balance better at the close of 1924. A sanctioned proposal includes the building of a branch line from Tabora to Kahama. These railway systems are in urgent need of further supplies of rolling stock in order to reap full advantage of the money expended. Coming to harbours progress has been made with the Kilindini scheme. In Tanganyika improvements to the value of 100,000*l.* are to be carried out to the existing customs wharf at Dar-es-Salaam. In the world of shipping the main development to record during the period covered by the Report is the admission of the Deutsch Ost Afrika Line, and the Holland East Africa Line to the East African Steam Conference, with the prospect that the elimination of rate cutting may lead to a higher level of freights during the year 1925. The freight space available has been more than adequate for requirements up to the present, but a more satisfactory state of affairs is expected to arise in the near future.

## CATALOGUES.

*Electric Railways.*—A brief history of the London railways and a very full account of the recent developments of the electric system on the Metropolitan Railway are given in a pamphlet issued by the Metropolitan-Vickers Electrical Company, Limited, Trafford-park, Manchester. The power station, high-tension transmission, sub-stations, permanent way, and rolling-stock are separately described, and the illustrations and letterpress are excellent.

*Switchboards.*—In the new edition of their catalogue of switchboards, the General Electric Company, Limited, Magnet House, Kingsway, London, W.C., have endeavoured to give the fullest information, both technical and commercial, with regard to these products. The catalogue includes a specimen estimate as a model for ascertaining the cost of a complete installation. This may be varied according to requirements, the figures for the items all being quoted in the catalogue.

*Oxygen Apparatus.*—A bound catalogue, issued by the British Oxygen Company, Limited, Angel-road, Upper Edmonton, London, N., contains nine sections dealing with gas cylinders, blow pipes, oxy-coal-gas blow pipes, metal-cutting apparatus, medical and rescue appliances, limelight apparatus, self-intensive liquefaction of gases, oxygen and other gas production plants, and valves. In all sections there are practical notes which will be of value to those who use this class of apparatus.

*Woodworking Machines.*—An interesting range of woodworking machines is dealt with in a catalogue received from Messrs. John Pickles and Son (Engineers), Limited, Hebden Bridge. Among the machines dealt with is a large high-speed frame-sawing machine, made in six sizes with capacities up to 54 in. square; a board-sawing machine; circular-saw benches; universal, band and pendulum sawing machines; planing, moulding, shaping, mortising, tenoning and sanding machines; and machines for grinding cutters and sharpening saws.

*Optical Instruments.*—Messrs. Adam Hilger, Limited, 75A, Camden-road, London, N.W.1, have sent us a copy of a very interesting catalogue of optical instruments and apparatus for the manufacture of which they have achieved an exceptionally high reputation. The catalogue, which is bound in paper-covered boards, and is divided into several sections rendered readily accessible by a thumb index, deals first with echelon diffraction gratings, Lummer-Gehrcke parallel plates, and accessory apparatus for spectroscopic work requiring very high resolving power. Several sections are devoted to spectrometers, spectrographs, spectroscopes, goniometers, calorimeters, micrometers, polarimeters, refractometers, and other instruments, many of which have been dealt with in our columns at various times. Particulars are also given of object glasses, lenses, prisms, plane-parallel glass, and other optical work, prices for which, as well as for the instruments referred to in the catalogue can be obtained from a separate price list issued monthly.

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LIMITS AND LIMIT GAUGING.—An informative booklet has just been published by the well-known firm of Messrs. Alfred Herbert, Limited, of Coventry, on the subject of limits as applied to examples of engineering workmanship. An opportunity is taken to describe the Wickman adjustable plain caliper gauge made by the firm, which consists of a hard cast-iron semi-circular frame having a pair of "not go" anvils mounted directly behind a pair of "go" distance pieces. An ingenious use of the elastic properties of hard steel balls enables the anvils to be set accurately to within 0·0001 in. of a specified dimension.

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PICTORIAL ROAD PLANS.—Many travellers who find the small-scale maps usually available of little assistance as guides will welcome Volume I of "On the Road," a handbook published by Messrs. Ed. J. Burrow and Co., Limited, of Kingsway, London, for The Dunlop Rubber Company. This book contains a number of pictorial road plans of the London district, and is the first of a series intended to include all routes in the United Kingdom. Each alternate page shows a broad, red line which indicates the main road, milestones being marked by short transverse lines. Postage-stamp-size drawings, with arrows giving the direction of the main road, are included at numerous places on each route. Copies may be had, price 6*d.* net, from the publishers.